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Geosciences Group
Westinghouse Hanford Company
Environmental Division

Date Published
February 1994

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Department of Energy
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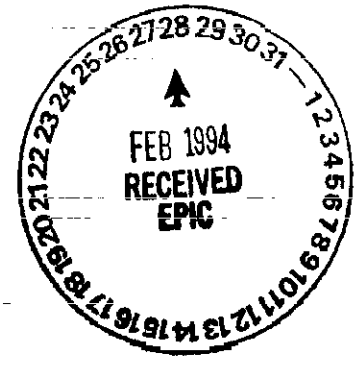

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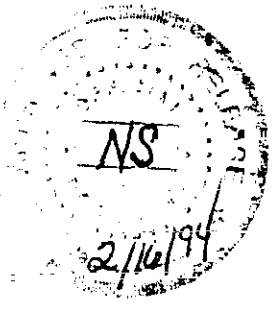

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EXECUTIVE SUMMARY

This report presents the annual hydrogeologic evaluation of 20 *Resource Conservation and Recovery Act of 1976* groundwater monitoring projects and 1 nonhazardous waste facility at the U.S. Department of Energy's Hanford Site. Most of the projects no longer receive dangerous waste; a few projects continue to receive dangerous waste constituents for treatment, storage, or disposal. The 20 RCRA projects comprise 30 waste management units. Ten of the units are monitored under groundwater quality assessment status because of elevated levels of indicator parameters. The impact of those units on groundwater quality, if any, is being investigated. If dangerous waste or waste constituents have entered groundwater, their concentration, distribution, and rate of migration are evaluated. Groundwater is monitored at the other 20 units to detect contamination, should it occur.

This report provides an interpretation of groundwater data collected at the waste management units between October 1992 and September 1993. Recent groundwater quality is also described for the 100, 200, 300, and 600 Areas and for the entire Hanford Site. Widespread contaminants include nitrate, chromium, carbon tetrachloride, tritium, and other radionuclides.

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CONTENTS

LIST OF TERMS

11-DCA	1,1-dichloroethane
111-TCA	1,1,1-trichloroethane
200 AAMS	200 Aggregate Area Management Study
A-29 Ditch	216-A-29 Ditch
AR	averaged replicate
BiPO4	bismuth phosphate
B Pond	216-B-3 Pond
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CFR	*Code of Federal Regulations*
CM	critical mean
CO_2	carbon dioxide
COD	chemical oxygen demand
CRDL	contractually required detection limit
CRQL	contractually required quantitation limit
CSL	chemical sewer line
CY	calendar year
DL	detection limit
DOE	U.S. Department of Energy
DST	double-shell tank
DWS	drinking water standard
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
FY	fiscal year
GPS	groundwater protection standard
GTF	Grout Treatment Facility
ICP	inductively coupled plasma
LERF	Liquid Effluent Retention Facility
LLBG	Low-Level Burial Grounds
LLWMA	Low-Level Waste Management Area
LOD	limit of detection
LOQ	limit of quantitation
LOW	liquid observation well
LWDF	Liquid Waste Disposal Facility
MCL	maximum contaminant level
MDC	minimum determined/detectable concentration
MDL	method detection limit
MEMO	Monitoring Efficiency Model
NCR	nonconformance report
NRDWL	Nonradioactive Dangerous Waste Landfill
NTU	nephelometric turbidity unit
PCE	tetrachloroethene
PNL	Pacific Northwest Laboratory
PUREX	Plutonium-Uranium Extraction (Plant)
QC	Quality Control
RADE	Request for Analytical Data Evaluation
RCRA	*Resource Conservation and Recovery Act of 1976*
REDOX	Reduction-Oxidation (Plant)
RL	Richland Operations Office
RSU	retrievable storage unit

LIST OF TERMS (cont.)

S-10 Facility	216-S-10 Pond and Ditch
SC	specific conductance
SST	single-shell tank
SWL	Solid Waste Landfill
TBP	tributyl phosphate
TCE	trichloroethylene
TEDB	Treated Effluent Disposal Basin
TEGD	Technical Enforcement Guidance Document
TOC	total organic carbon
TOX	total organic halogen
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
TSD	treatment, storage, and/or disposal
U-12 Crib	216-U-12 Crib
WAC	*Washington Administrative Code*
WHC	Westinghouse Hanford Company
WMA	Waste Management Area
WP	Water Pollution
WS	Water Supply
WWQS	Washington Water Quality Standard

METRIC CONVERSION CHART

INTO METRIC		
If you know	Multiply by	To get
Length		
inches	2.54	centimeters
feet	30.48	centimeters
Volume		
gallons	3.786	liters
cubic feet	0.02832	cubic meters
Temperature		
°Fahrenheit	Subtract 32°, then multiply by 5/9ths	°Celsius
Pressure		
inches water	1.87	mm Hg
inches water	249	pascal (Pa)
OUT OF METRIC		
Length		
centimeters	0.3937	inches
meters	3.28	feet
Volume		
milliliters	1.247×10^{-3}	cubic feet
liters	0.264	gallons
cubic meters	35.31	cubic feet
Temperature		
°Celsius	Multiply by 9/5ths, then add 32°	°Fahrenheit
Pressure		
mm Hg	0.5353	inches water
pascal (Pa)	4.02×10^{-3}	inches water

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LIST OF FIGURES

LIST OF TABLES

ANNUAL REPORT FOR RCRA GROUNDWATER MONITORING PROJECTS AT HANFORD SITE FACILITIES FOR 1993

1.0 INTRODUCTION

M. J. Hartman
Westinghouse Hanford Company

This report presents the annual evaluation of 20 *Resource Conservation and Recovery Act of 1976* (RCRA) groundwater monitoring projects and 1 nonhazardous waste facility at the U.S. Department of Energy's (DOE) Hanford Site. It presents interpretations of analytical data received between December 1992 and November 1993. The November 1993 cutoff date represents results from samples collected through September 30, 1993. These data were presented in the quarterly reports from October 1992 through September 1993 (DOE-RL 1993a, 1993b, 1993c, 1994). The reference list for this chapter includes a list of all quarterly and annual reports since RCRA groundwater monitoring began at the Hanford Site (Section 1.1.2).

DataChem Laboratories performs hazardous chemical analyses; International Technologies Corporation performs radiochemical analyses. Both contracts are administrated by Pacific Northwest Laboratory.

The RCRA projects are monitored under one of three programs: (1) a background monitoring program, (2) an indicator parameter evaluation program, or (3) a groundwater quality assessment program. When a groundwater monitoring system has been installed, a background monitoring program begins. Samples and water levels from upgradient monitoring well(s) must be obtained and analyzed quarterly for 1 year to obtain background data on the quality of the groundwater. All of the RCRA sites at the Hanford Site have completed their initial background monitoring programs. Background monitoring was reinstated at the 1301-N site following an assessment program.

After 1 year, the indicator evaluation program commences, and groundwater samples and water levels must be taken semiannually. Data obtained through the indicator evaluation program are compared with background data; if a significant statistical change over background has occurred, a groundwater quality assessment plan must be implemented. Table 1-1 lists all of the RCRA facilities and waste management units and their monitoring program status. Figure 1-1 is an index map for locating all of the RCRA facilities on the Hanford Site.

The constituent lists for laboratory analyses are established in accordance with the requirements of 40 *Code of Federal Regulations* (CFR) 265.92. The contamination indicator parameters are specified in 40 CFR 265.92(b)(3). The parameters establishing groundwater quality are specified in 40 CFR 265.92(b)(2). The drinking water standards are required by 40 CFR 265.92(b)(1) and are specified in Appendix III of that chapter. Site-specific parameters (including radionuclides) are determined from

Table 1-1. Status of Hanford Site RCRA Interim-Status Groundwater Monitoring Projects as of September 30, 1993. (sheet 1 of 3)

Project (date initiated)	Program status			Regulatory requirements
	Background monitoring	Indicator parameter evaluation	GW quality assessment	
100-D Ponds (4/92)		X		40 CFR 265.93(d) WAC 173-303-400
183-H Basin (6/85)			X (6/85)	*Consent Agreement and Compliance Order*[a]
1301-N LWDF (12/87)	X[b]			40 CFR 265.93(d) WAC 173-303-400
1324-N/NA Pond (12/87)			X (5/89) Spe cond, TOX	40 CFR 265.93(d) WAC 173-303-400
1325-N LWDF (12/87)		X		40 CFR 265.93(b) WAC 173-303-400
GTF (8/85)		X		40 CFR 265.93(b) WAC 173-303-400
216-B-3 Pond (11/88)			X (5/90) TOX	40 CFR 265.93(d) WAC 173-303-400
216-A-29 Ditch (11/88)			X (6/90) Spe cond	40 CFR 265.93(d) WAC 173-303-400
216-A-36B Crib (5/88)		X		40 CFR 265.93(b) WAC 173-303-400
216-A-10 Crib (11/88)		X		40 CFR 265.93(b) WAC 173-303-400
216-B-63 Trench (8/91)		X		40 CFR 265.92(c) WAC 173-303-400
216-S-10 Pond (8/91)		X		40 CFR 265.92(c) WAC 173-303-400
216-U-12 Crib (9/91)			X (1/93) Spe cond	40 CFR 265.93(b) WAC 173-303-400
LERF (7/91)		X		40 CFR 265.92(c) WAC 173-303-400
2101-M Pond (8/88)		X		40 CFR 265.93(b) WAC 173-303-400

Table 1-1. Status of Hanford Site RCRA Interim-Status Groundwater Monitoring Projects as of September 30, 1993. (sheet 2 of 3)

Project (date initiated)	Program status			Regulatory requirements
	Background monitoring	Indicator parameter evaluation	GW quality assessment	
LLBG				
WMA 1 (9/88)			X (12/89) Spe cond	40 CFR 265.93(d) WAC 173-303-400
WMA 2 (9/88)		X		
WMA 3 (10/88)			X (12/89) TOX	
WMA 4 (10/88)		X		40 CFR 265.93(b) WAC 173-303-400
WMA 5 (3/92)		X		
SST				
WMA-A-AX (2/90)		X		40 CFR 265.92(c) WAC 173-303-400
WMA-B-BX-BY (2/90)		X		
WMA-C (2/90)		X		
WMA-S-SX (10/91)		X		
WMA-T (2/90)			X (7/93) Spe cond	
WMA-TX-TY (9-10/91)			X (7/93) Spe cond	
WMA-U (10/9)		X		
300 Area Process Trenches (6/85)			X (6/85)	*Consent Agreement and Compliance Order*[a]

Table 1-1. Status of Hanford Site RCRA Interim-Status Groundwater Monitoring Projects as of September 30, 1993. (sheet 3 of 3)

Project (date initiated)	Program status			Regulatory requirements
	Background monitoring	Indicator parameter evaluation	GW quality assessment	
NRDWL (10/86)		X		40 CFR 265.93(c) WAC 173-303-400

Note: An X and date in the fourth column indicates the following: (1) the date that the assessment was initiated and (2) the indicator parameter that triggered assessment monitoring.

[a]Ecology and EPA 1986.

[b]Background monitoring was reinstated in March 1993.

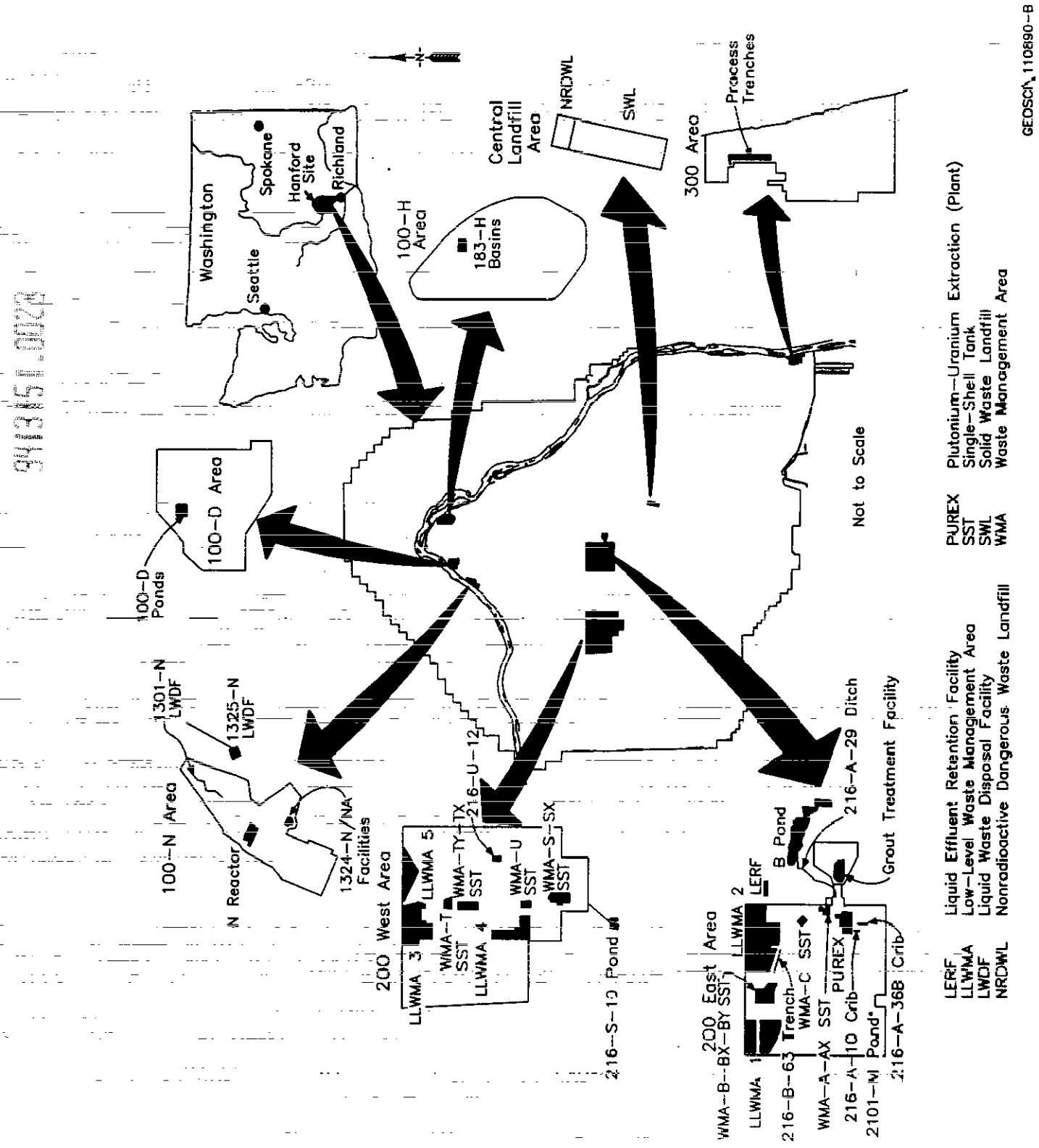
CFR = *Code of Federal Regulations*.
GTF = Grout Treatment Facility.
GW = groundwater.
LERF = Liquid Effluent Retention Facility.
LLBG = Low-Level Burial Grounds.
LWDF = Liquid Waste Disposal Facility.
NRDWL = Nonradioactive Dangerous Waste Landfill.
Spe cond = specific conductance.
SST = single-shell tanks.
TOX = total organic halogen.
WAC = *Washington Administrative Code*.
WMA = Waste Management Area.

evaluation of the waste stream (or source) associated with the facility. Additional site-specific constituents may be included to aid in tracking groundwater movement and the influence of other facilities. In some cases, an Appendix IX list of constituents (40 CFR 264) is analyzed to establish a baseline for future comparisons and analyses.

The Solid Waste Landfill (SWL) is a solid waste disposal facility. It is not a RCRA site and is not addressed under the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1992). The current operations of the SWL fall under the regulations of *Washington Administrative Code* (WAC) 173-304, and a permit application for the facility under this regulation has been prepared (DOE-RL 1990). The SWL is included in this report because of uncertainty in the final regulatory authority for the site and because of the interest of the Washington State Department of Ecology (Ecology) in all aspects of Hanford Site operations.

The groundwater monitoring programs described in this document comply with the following WAC regulations: (1) "Dangerous Waste Regulations," WAC 173-303-400, for hazardous waste; and (2) "Minimum Functional Standards for Solid Waste Handling," WAC 173-304-490, for nonhazardous waste. The

Figure 1-1. Locations of the RCRA Groundwater Monitoring Projects and Landmarks on the Hanford Site.



projects meet the federal requirements for "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," 40 CFR 265, Subpart F; and "Criteria for Classification of Solid Waste Disposal Facilities and Practices," 40 CFR 257, for nonhazardous waste.

40 CFR Part 265.94, "Recordkeeping and Reporting," requires that for indicator evaluation monitoring projects, concentrations and any changes in measured parameters for each groundwater monitoring well must be identified, and the locations of the monitoring wells must be shown to continue to satisfy regulatory criteria (265.94[a][2]). For assessment level monitoring, a report of the results of the groundwater quality assessment program must be submitted annually. The report must include the calculated (or measured) rate of migration of hazardous waste or hazardous waste constituents in the groundwater (40 CFR 265.94[b][2]). An annual report for solid waste landfills is required under WAC 173-304.

This report is organized by geographical area. Chapter 2.0 presents an overview of Hanford Site hydrogeology. Chapters 3.0, 4.0, 5.0, and 6.0 discuss the 100, 200, 600, and 300 Areas, respectively. Each chapter begins with a description of the hydrogeologic setting of the area, followed by sections covering individual RCRA sites. Appendix A provides a brief description of the quality control program for sample analysis and a summary of the year's activities. Appendix B describes the data evaluation process and activities during the year. Appendix C provides data tables for background groundwater quality and methods of statistical evaluation.

Each subsection describing an individual RCRA site begins with an overview of the facility, a summary of 1993 RCRA activities, and a summary of other activities related to the hydrogeology of the site. Next, the sampling and analysis program is described, including well locations, the constituent list, and sampling frequency. For sites in indicator evaluation monitoring, a section on groundwater chemistry discusses elevated constituents and their changes with time, and results of statistical evaluations. For sites in assessment monitoring, the groundwater chemistry section describes concentration histories of waste constituents and their distribution. For all sites, the final subsections describe the direction of groundwater flow, the rate of flow, and an evaluation of the monitoring network.

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2.0 HANFORD SITE HYDROGEOLOGY

M. J. Hartman
Westinghouse Hanford Company

This chapter presents a summary of the geology and hydrology of the Hanford Site. Additional detail is available from Delaney et al. (1991) and DOE (1988).

2.1 SITE GEOLOGY

The information in this section is summarized from Delaney et al. (1991) and other sources as noted. The Hanford Site is underlain by Miocene-aged basalt of the Columbia River Basalt Group, and late Miocene to Pleistocene sediments.

The Columbia River Basalt Group comprises an assemblage of tholeiitic, continental flood basalts that cover an area of more than 160,000 km^2 (63,000 mi^2). Sediments of the Ellensburg Formation form interbeds between basalt flows. The Levey interbed is the uppermost unit of the Ellensburg Formation. It is a tuffaceous sandstone to siltstone and, at the Hanford Site, it is found only beneath the 300 Area. The Rattlesnake Ridge interbed is the shallowest interbed beneath the rest of the Hanford Site. It is up to 33 m (108 ft) thick and includes clay, siltstone, and sandstone.

The suprabasalt sedimentary sequence beneath the Hanford Site is up to 230 m (750 ft) thick. It pinches out against areas where the basalt has been uplifted. The suprabasalt sediments are dominated by laterally extensive deposits assigned to the late Miocene to Pliocene-aged Ringold Formation and the Pleistocene-aged Hanford formation (informal name). The remainder of the sequence comprises localized strata assigned to the informally defined Plio-Pleistocene unit, early "Palouse" soil, and pre-Missoula gravels.

2.1.1 Stratigraphy of the Ringold Formation

Lindsey (1991) describes the Ringold Formation on the basis of sediment facies associations. The facies associations are summarized as follow:

- Fluvial Gravel Facies--Dominantly clast-supported, granule to cobble gravel with a sandy matrix. Deposited in a gravelly fluvial system characterized by wide, shallow, shifting channels.
- Fluvial Sand Facies--Quartzo-feldspathic sands, commonly forming fining-upwards sequences less than 1 m (3 ft) to several meters thick. Deposited in wide, shallow channels incised into a muddy flood plain.
- Overbank Facies--Laminated to massive silt, silty fine-grained sand, and paleosols containing variable amounts of $CaCO_3$. Deposited in a flood plain.

- Lacustrine Facies--Plane laminated to massive clay with thin silt and silty sand interbeds. Deposited in a lake under standing water or deltaic conditions.

The Ringold Formation comprises alternating fine- and coarse-grained, semi-indurated sediments. Lindsey (1991) designates fluvial sand and gravel-dominated sequences A (oldest) through E (youngest) (Figure 2-1). Not all of the fluvial sequences are continuous beneath the Hanford Site.

The lowest Ringold deposits consist of up to 46 m (150 ft) of fluvial gravel, designated unit A. Unit A is not found in the vicinity of the 300 and 1100 Areas or near the 100-H and 100-F Areas.

The lower mud unit, comprising overbank and lacustrine deposits, lies over unit A. The lower mud unit is up to 43 m (140 ft) thick.

Fluvial gravel unit B lies over the lower mud unit. Unit B is up to 25 m (82 ft) thick, but is not present beneath the 200 Areas.

Deposits typical of the overbank facies association overlie unit B throughout the Hanford Site. Where unit B is absent, these overbank deposits interfinger with the lower mud sequence.

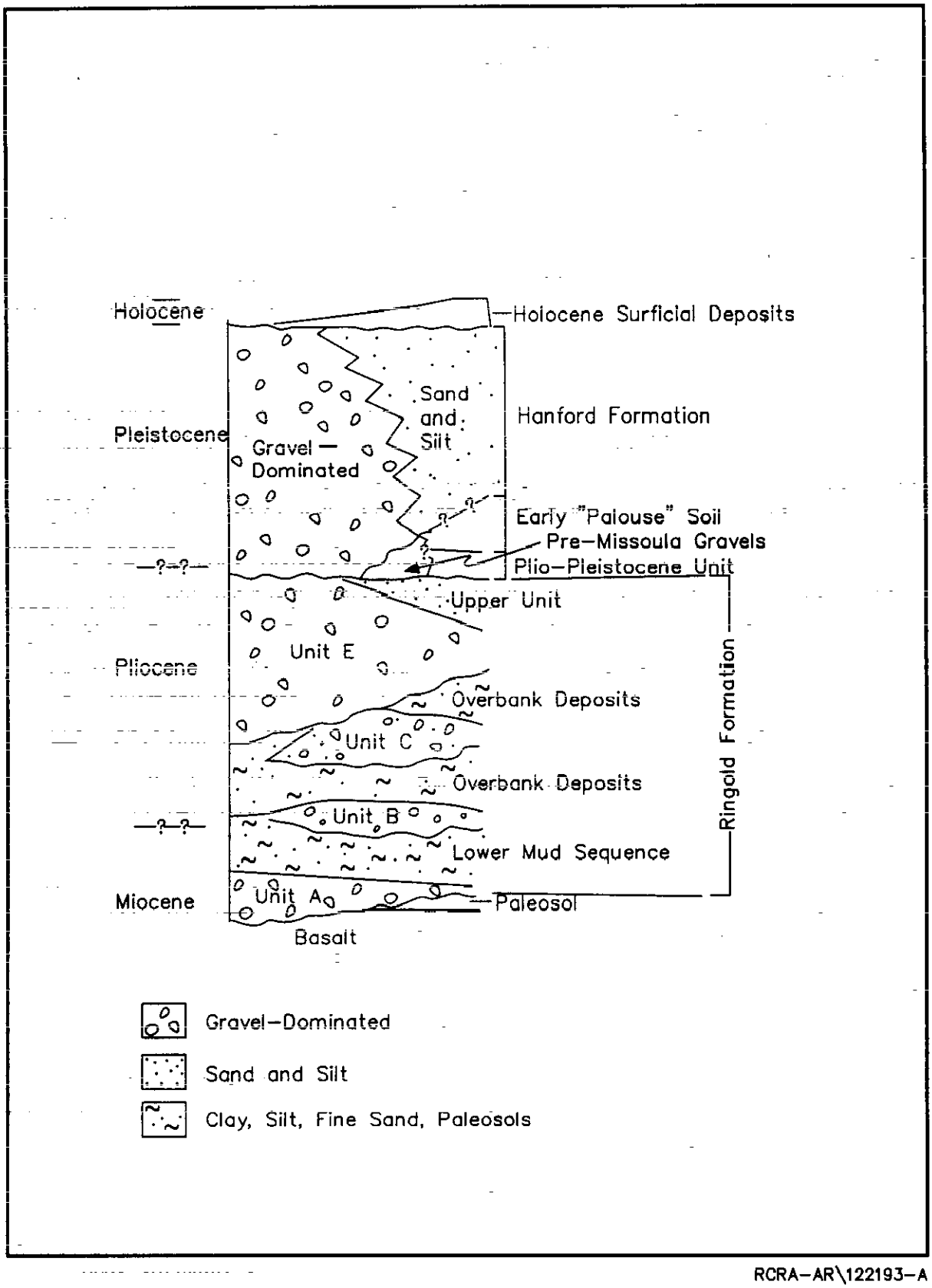
Another fluvial gravel-dominated sequence, unit C, is found in a relatively narrow linear tract trending northwest to southeast. It is up to 35 m (115 ft) thick near the 100-B/C Area, but it is absent north of the 100-N and 100-F Areas. The unit trends to the southeast in a linear tract stretching from east of 200 East Area to near the city of Richland.

Another sequence of overbank deposits overlies unit C. Thin fluvial sands are present locally.

The uppermost fluvial gravel-dominated sequence in the Ringold Formation, unit E, is the most widespread of the gravel sequences. Unit E is up to 30 m (100 ft) thick near the 100-B/C Area, and pinches out north of the 100-D Area and east of Gable Gap. Laterally equivalent strata near the 100-F and 100-H Areas consist of overbank deposits with minor intercalated fluvial sand. Unit E is found throughout the Cold Creek syncline, forming a west-thickening wedge that is 30 to 40 m (98 to 130 ft) thick south and east of 200 East Area, and 91 m (300 ft) thick south and west of 200 West Area. Near the 300 Area the overbank deposits beneath unit E are absent and unit E overlies or truncates underlying coarse-grained sequences (unit C or B).

More interbedded fluvial sand and overbank deposits lie over unit E in some areas of the Hanford Site. Erosional remnants of these deposits are found south and east of 200 East Area and near 200 West Area. North of the 100-F and 100-N Areas, fluvial sands pinch out and overbank deposits dominate the sediments.

Figure 2-1. Generalized Stratigraphy of the Suprabasalt Sediments Beneath the Hanford Site (Delaney et al. 1991).



RCRA-AR\122193-A

2.1.2 Post-Ringold, Pre-Hanford Deposits

Thin alluvial deposits between the Hanford and Ringold Formations are referred to informally as the: (1) Plio-Pleistocene unit, (2) pre-Missoula gravels, and (3) early "Palouse" soil.

The Plio-Pleistocene unit is laterally discontinuous and is up to 25 m (82 ft) thick. It is found in the vicinity of the 200 West Area. Pre-Missoula gravels, up to 25 m (82 ft) thick, are found east and south of 200 East Area. It is unclear whether the pre-Missoula gravels overlie or interfinger with the early "Palouse" soil and Plio-Pleistocene unit. The early "Palouse" soil comprises up to 20 m (65 ft) of silt and fine-grained sand. It is found around the 200 West Area.

2.1.3 Stratigraphy of the Hanford Formation

The Hanford formation consists of gravel-dominated deposits and sand/silt-dominated deposits. It is up to 64 m (210 ft) thick near the 200 Areas.

The gravel-dominated deposits comprise coarse-grained sand and gravel with boulders. Matrix commonly is lacking in these gravels. Gravels dominate the formation in the 100 Areas, the northern part of the 200 East Area, and the eastern Hanford Site, including the 300 Area. The gravels generally become finer to the south in the 200 Areas. The gravel-dominated facies of the Hanford formation were deposited by high-energy glacial flood waters in or immediately adjacent to the main cataclysmic flood channels.

The sand/silt-dominated deposits comprise two facies: (1) laminated sand and (2) rhythmite. The laminated sand facies consists of fine- to coarse-grained sand that may contain small pebbles or pebble-gravel interbeds less than 20 cm (8 in.) thick. This facies is common in the 200 Areas. It was deposited adjacent to main flood channels as it spilled out of the channels. The rhythmite facies consists of silt and fine- to coarse-grained sand that commonly display normally graded rhythmites a few centimeters (inches) to tens of centimeters (inches) thick in outcrop. These sediments were deposited under slack water conditions and in backflooded areas. The facies is found within and south of the 200 Areas.

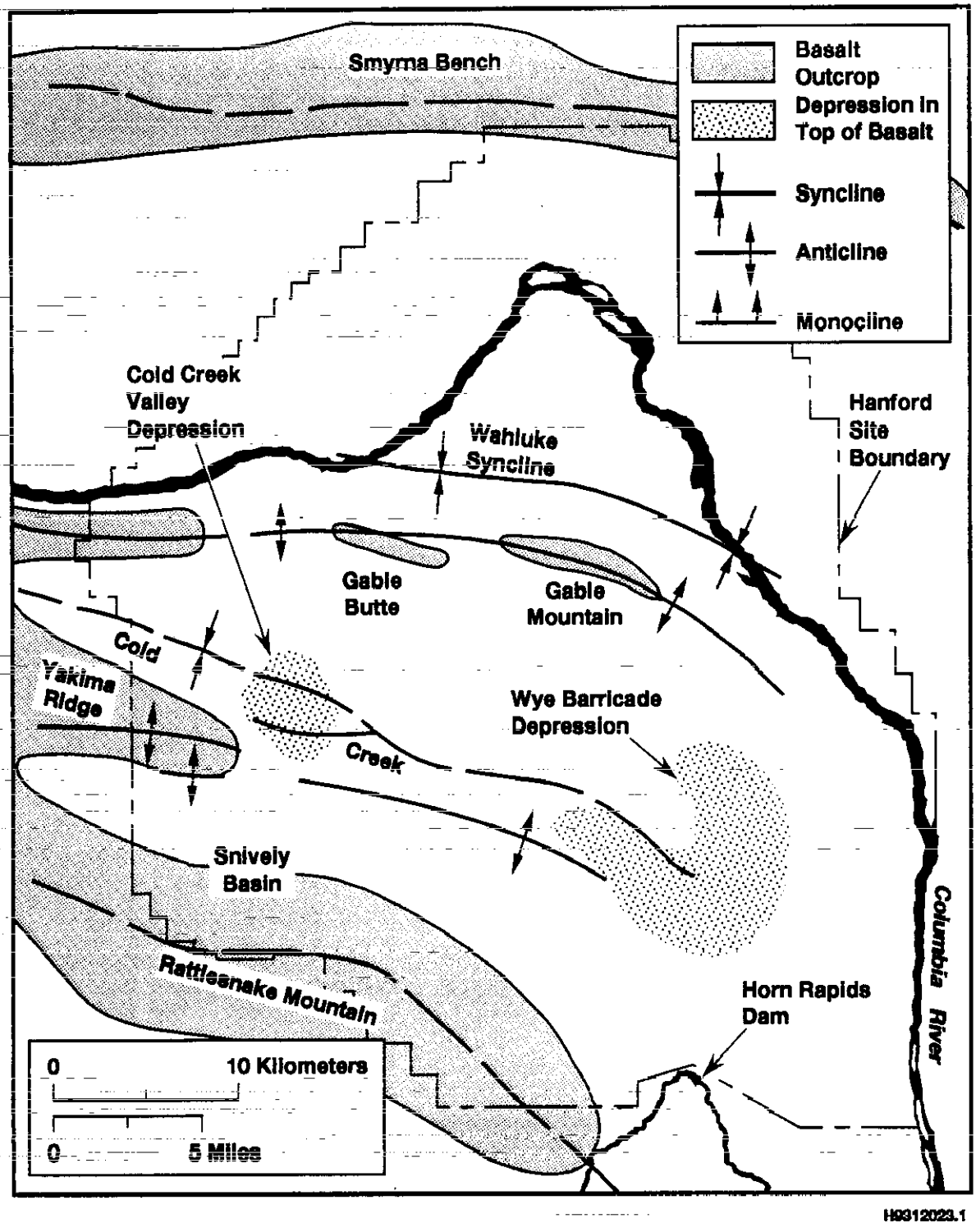
2.1.4 Holocene Surficial Deposits

Holocene surficial deposits form a thin (<5-m [<16-ft]) veneer across much of the Hanford Site. The deposits comprise silt, sand, and gravel.

2.1.5 Structural Geology of the Hanford Site

The Hanford Site is located in the Pasco Basin, one of the largest structural basins on the Columbia Plateau. The Pasco Basin is divided by the Gable Mountain anticline into the Wahluke and Cold Creek synclines (Figure 2-2).

Figure 2-2. Geologic Structure of the Hanford Site (Delaney et al. 1991).



The Cold Creek syncline is an asymmetric and relatively flat-bottomed structure. The 200 Areas lie on the northern flank and the bedrock dips gently to the south of the Cold Creek syncline. The 300 Area lies at the eastern end of the Cold Creek syncline.

The Wahluke syncline contains the 100 Areas. It is an asymmetric and relatively flat-bottomed structure similar to the Cold Creek syncline. The northern limb dips gently to the south; the steepest limb is adjacent to the Gable Mountain anticline.

The Umtanum Ridge-Gable Mountain structural trend is a segmented anticlinal ridge extending in an east-west direction and passing between the 200 and 100 Areas. On the Hanford Site the Umtanum Ridge segment plunges eastward and joins the Gable Mountain-Gable Butte segment.

2.2 SITE HYDROLOGY

2.2.1 Surface Hydrology

Primary surface-water features associated with the Hanford Site are the Columbia River and its tributary, the Yakima River. West Lake, about 4 ha (10 acres) in size and less than 1 m (3 ft) deep, is the only natural lake on the Hanford Site.

The Columbia River flows through the northern part and along the eastern border of the Hanford Site. Flow along this section of the river, which is called the Hanford Reach, is controlled by Priest Rapids Dam upstream of the Hanford Site. River stage recorders, consisting of pressure transducers and data loggers, have recently been installed in the Columbia River at the 100-B/C, 100-N, 100-H, 100-F, and 300 Areas. An older, chart-style recorder has been operating at the 100-N Area in the past. Figure 2-3 shows the average weekly river stage for the past year at the 100-B/C, 100-H, 100-F, and 300 Areas. Discharge at Priest Rapids Dam is also illustrated. The river stage graphs are parallel, with some damping of amplitude further downstream (e.g., 300 Area).

Riverbank springs have been observed and sampled along the Hanford Reach (McCormack and Carlile 1984; Dirkes 1990). Hanford Site-origin contaminants have been detected in spring water along the Hanford Site. The type and concentrations of contaminants in the spring water are similar to those known to exist in the groundwater near the river.

Approximately one-third of the Hanford Site is drained by the Yakima River system. Cold Creek and its tributary, Dry Creek, are ephemeral streams within the Yakima River drainage system.

Table 2-1 lists the chemical composition of river water at the Hanford Site. Precipitation at the Hanford Site contains very few dissolved solids. Columbia River water is low in dissolved solids. Yakima River water contains higher concentrations of some constituents, which may be influenced by anthropogenic activity (DOE-RL 1992).

Figure 2-3. Weekly Average Columbia River Stage at the Hanford Site and Weekly Average Discharge at Priest Rapids Dam.

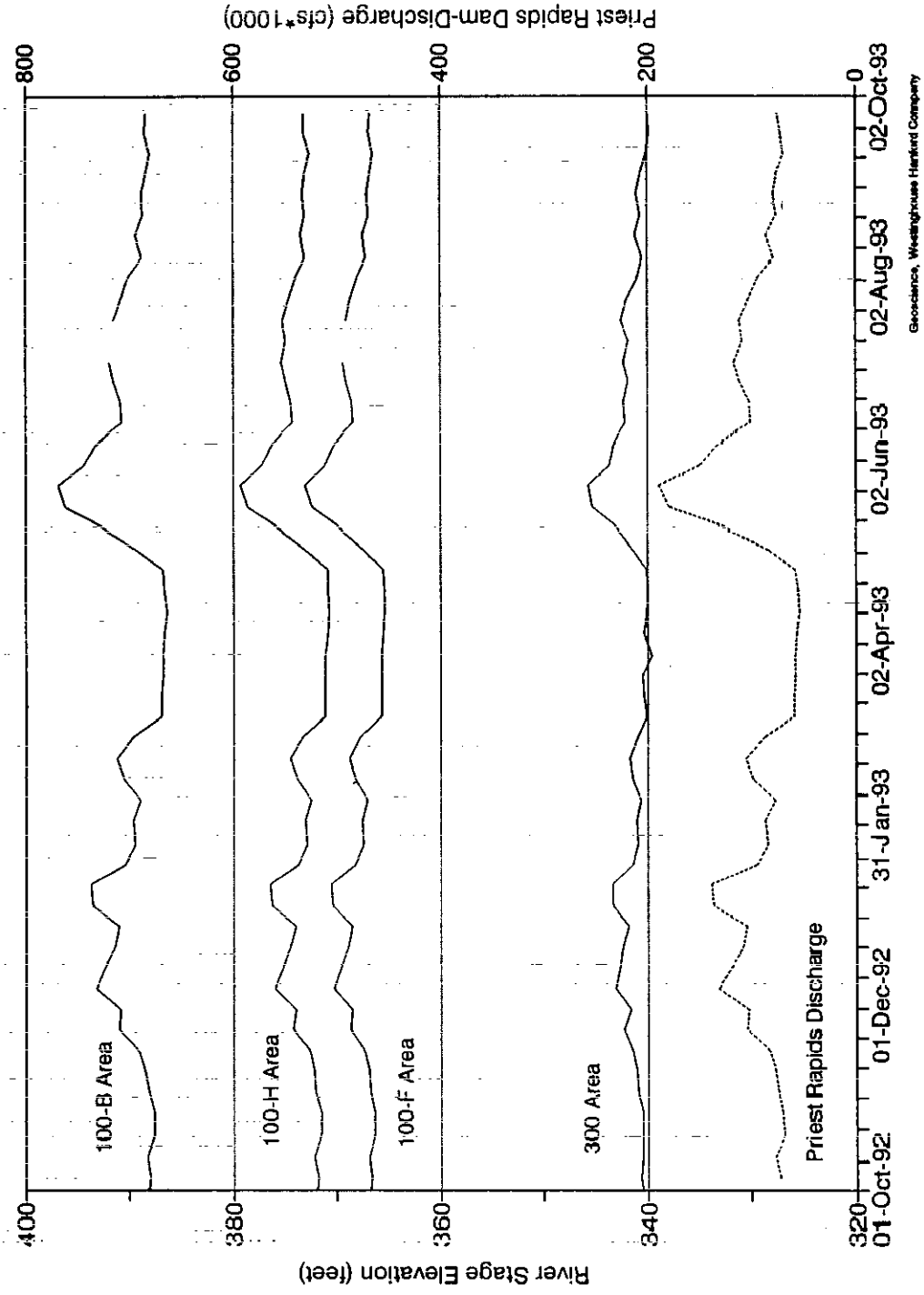


Table 2-1. Range of Chemical Constituents in Columbia and Yakima River Water (DOE 1988, pp. 3.4-3 and 3.4-4).

Parameter	Units	Range[a]	
		Columbia River at Vernita	Yakima River at Horn Rapids
Calcium	mg/L	17.3 - 22.2	12.7 - 30.3
Chlorine	mg/L	0.9 - 1.1	2.2 - 6.9
Fluorine	mg/L	0.13 - 0.32	0.18 - 0.22
Potassium	mg/L	0.42 - 0.91	1.3 - 3.0
Magnesium	mg/L	4.0 - 5.2	4.2 - 10.7
Sodium	mg/L	2.2 - 2.4	6.2 - 16.3
Nitrate (as NO_3)	mg/L	0.15[b]	0.4 - 4.0
Silicon	mg/L	1.8 - 2.1	8.0 - 10.7
Sulfate	mg/L	9.13 - 13.4	5.4 - 17.9
Total carbon	mg/L	13.9 - 16.3	14.9 - 29.5
Total organic carbon	mg/L	1.2 - 2.0	1.7 - 3.3
Tritium	pCi/L	81.1 - 96.3	40.4 - 45.2
pH	--	7.94 - 8.71	7.25 - 8.78
Turbidity	NTU	1.1 - 3.5	9.2 - 23.5
Alkalinity	mg/L	53.0 - 62.0	51 - 121
Conductivity	μmho/cm	123 - 152	122 - 291
Iron	mg/L	<0.03	<0.015 - 0.066
Manganese	mg/L	<0.01	0.012 - 0.028

[a]Samples were collected in April, July, and November 1985 and January and May 1986.
[b]Only one sample analyzed for nitrate.
NTU = nephelometric turbidity units.

2.2.2 Hydrogeologic Units

Hydrogeologic units beneath the Hanford Site include: (1) the vadose zone, (2) an aquifer system in the suprabasalt sediments, and (3) a series of confined aquifers in the basalts and interbeds. This document will focus on the units above the basalts. The source of the following information is Delaney et al. (1991) unless otherwise indicated. Hydraulic properties of various hydrologic units are listed in Table 2-2.

The vadose zone at the Hanford Site includes Holocene surficial deposits, the Hanford formation, and in some areas, portions of the Ringold Formation. In the 100 Areas the water table is located near the Hanford-Ringold contact and the vadose zone consists of poorly sorted gravel, sand, and silt. In the 200 Areas, unsaturated sediments include Ringold unit E and the units above it (see Section 2.1). Only the Hanford formation is continuous throughout the vadose zone in the 200 Areas. The vadose zone beneath the 300 and 1100 Areas consists almost entirely of the Hanford formation. The vadose zone is less than 30 m (100 ft) thick in areas near the Columbia River (i.e., the 100, 300, and 1100 Areas). The vadose zone beneath the 200 Areas is up to 104 m (340 ft) thick.

The saturated sediments of the Hanford and Ringold Formations make up a series of aquifers and aquitards that has been referred to as the *suprabasalt aquifer system*. The shallowest producing layer within the system at a given location is called the *uppermost aquifer*. In general, the sand- and gravel-dominated stratigraphic units (see Figure 2-1) form aquifers and the overbank/lacustrine deposits form aquitards.

The uppermost aquifer in the 100 Areas comprises unconfined sand and gravel of Ringold unit E or the Hanford formation. In the 200 West Area the uppermost aquifer is contained in the Ringold Formation under unconfined to locally confined conditions. In the 200 East Area the uppermost aquifer occurs in the Hanford and Ringold Formations under unconfined to locally confined conditions. The aquifer pinches out north of the 200 East Area where the basalt is above the water table. The uppermost aquifer at the 300 and 1100 Areas is dominated by the fluvial gravels of the Ringold Formation.

Water enters the uppermost aquifer from precipitation, deeper aquifers, influent streams, and artificial sources such as liquid effluent disposal and irrigation.

Coarse-grained units deeper in the Ringold Formation are isolated beneath fine-grained units, forming a series of confined aquifers. Hydrologic data on these aquifers are limited. There is an upward gradient between these shallow, confined aquifers and the unconfined aquifer in the 100-H Area.

2.2.3 Groundwater Flow

Figure 2-4 is a water table map of the Hanford Site for June 1993. Groundwater flow in the unconfined aquifer is inferred to be generally from west to east, discharging to the Columbia River. Artificial recharge from

Table 2-2. Hydraulic Parameters for Various Areas and Geologic Units at the Hanford Site (Delaney et al. 1991).

Location	Interval tested	Hydraulic conductivity (m/d) (ft/d)	Transmissivity (m^2/d) (ft^2/d)	Data source
100 Area	Rattlesnake Ridge interbed	0 - 30.5 (0 - 100)	--	Gephart et al. (1979)
100 Area	Ringold unit E	8.8 - 396 (29 - 1,300)	534 - 2,480 (5,750 - 26,700)	Liikala et al. (1988)
200 Area	Rattlesnake Ridge interbed	--	0.74 - 108 (8 - 1,165)	Graham et al. (1981, 1984)
200 West Area	Ringold unit E	0.18 - 61 (0.6 - 200)	--	Last et al. (1989)
1100 Area	Ringold units C and B	0.09 - 1.5 (0.3 - 5)	--	Lindberg and Bond (1979)
1100 Area	Ringold overbank deposits	0.00024 - 0.03 (0.0008 - 0.1)	--	Lindberg and Bond (1979)
300 Area	Levey interbed	0.003 - 305 (0.01 - 1,000)	--	DOE-RL (1990)
300 Area	Ringold Formation	0.58 - 3,050 (1.9 - 10,000)	--	DOE-RL (1990)
300 Area	Hanford formation	3,350 - 15,200 (11,000 - 50,000)	--	DOE-RL (1990)

liquid effluent disposal has locally altered groundwater flow and raised the water table. The most notable examples of this are in the 200 West Area and east of the 200 East Area.

2.2.4 Groundwater Chemistry

The chemical composition of unconfined groundwater at the Hanford Site is influenced by interactions with the Ringold sediments, primarily the basaltic grains (DOE-RL 1992). The average and maximum concentrations of inorganic constituents are listed in Table 2-3. The listed values were derived from wells located upgradient (to the west) of Hanford Site activities.

Hanford Site operations have introduced chemical and radiological contaminants to the groundwater in the uppermost aquifer. Contaminant plumes originate in the operational areas. Contamination is also present from offsite sources, e.g., nitrate from agricultural practices.

Figures 2-5 through 2-9 are contour maps showing the distribution of the most widespread contaminants in the uppermost aquifer of the Hanford Site. The maps were constructed from data collected from shallow wells between January 1991 and September 1993. Anomalous data points were removed and values were averaged where more than one result existed.

Figure 2-5 shows the distribution of tritium in the uppermost aquifer. Sources of tritium contamination are, or have been, effluent storage or disposal sites in the reactor areas and the 200 Areas. Tritium contamination from the 200 Areas has moved in a widespread plume toward the east. It appears that tritium contamination also has moved northward between Gable Mountain and Gable Butte. Once through this "gap," the tritium contamination migrates toward the northwest.

Figure 2-6 illustrates gross beta activity in the uppermost aquifer. The highest observed activities are in the 200 Areas and in the 100-N Area. Like the tritium plume, the gross beta plume has moved from the 200 East Area through Gable Gap.

The gross beta plumes in the 200 Areas and the plume moving through Gable Gap coincide with the ^{99}Tc plume in those areas (see Figure 2-7). Technetium-99 is a beta emitter. A group of wells near the Columbia River due east of the 200 Areas also show elevated ^{99}Tc. It is not known whether this plume is connected to contamination in the 200 Areas.

Figure 2-8 shows the distribution of ^{129}I in the uppermost aquifer. Contaminant plumes are moving toward the east from the 200 Areas. Smaller areas of contamination are also observed near the 300 Area.

Figure 2-9 illustrates nitrate distribution in the uppermost aquifer. Nitrate contamination above the drinking water standard (45,000 ppb) is observed at locations throughout the Hanford Site.

Table 2-3. Mean and Maximum Concentrations of Inorganic Constituents in Unconfined Groundwater Unaffected by Hanford Site Operations (DOE-RL 1992, Tables 5-9 and 5-11). (sheet 1 of 2)

Parameter	Units	Mean ± 1 standard deviation (sample size)	Provisional threshold value[a]
Aluminum	ppb	<200 (50)	<200
Ammonium	ppb	<50 (18)	<120
Arsenic	ppb	<5 (14)	10
Barium	ppb	41 ± 20 (53)	68.5
Beryllium	ppb	<5 (16)	<5
Bismuth	ppb	<5 (4)	<5
Boron	ppb	<100 (35)	<100
Cadmium	ppb	<10 (16)	<10
Calcium	ppb	38,542 ± 11,023 (53)	63,600
Chloride-Low	ppb	5,032 ± 1,774 (53)	8,690
Chloride-High	ppb	23,296 ± 2,463 (14)	28,500
Chloride-All	ppb	8,848 ± 7,723 (67)	Not calculated
Chromium	ppb	<30 (8)	<30
Copper	ppb	<30 (50)	<30
Fluoride	ppb	437 ± 131[b] (47)	775[b]
Iron-Low	ppb	<50 (34)	86
Iron-Mid	ppb	115 ± 52 (7)	291
Iron-High	ppb	494 ± 118 (12)	818
Iron-All	ppb	149 ± 199 (53)	Not calculated
Lead	ppb	<5 (15)	<5
Magnesium	ppb	11,190 ± 2,578 (53)	16,480
Manganese-Low	ppb	<20 (33)	24.5
Manganese-High	ppb	118 ± 17 (20)	163.5
Manganese-All	ppb	50 ± 55 (53)	Not calculated
Mercury	ppb	<0.1 (14)	<0.1
Nickel	ppb	<30 (23)	<30
Nitrate	ppb	5,170 ± 3,576 (78)	12,400
Phosphate	ppb	<1,000[c]	<1,000

Table 2-3. Mean and Maximum Concentrations of Inorganic Constituents in Unconfined Groundwater Unaffected by Hanford Site Operations (DOE-RL 1992, Tables 5-9 and 5-11). (sheet 2 of 2)

Parameter	Units	Mean ± 1 standard deviation (sample size)	Provisional threshold value[a]
Potassium	ppb	4,993 ± 1,453 (53)	7,975
Selenium	ppb	<5 (14)	<5
Silver	ppb	<10[d]	<10
Silicon	ppb	18,152 ± 4,974 (35)	26,500
Sodium	ppb	15,774 ± 6,784 (53)	33,500
Strontium	ppb	164 ± 47 (43)	264.1
Sulfate	ppb	30,605 ± 22,611 (67)	90,500
Uranium	ppb	1.7 ± 1.2	3.43
Vanadium	ppb	9 ± 4 (18)	15
Zinc-Low	ppb	<50 (36)	<50
Zinc-High	ppb	247 ± 165 (17)	673
Zinc-All	ppb	95 ± 140 (53)	Not calculated
Field alkalinity	ppb	137,758 ± 33,656 (31)	215,000
Lab alkalinity	ppb	137,717 ± 29,399 (52)	210,000
Field pH	--	7.57 ± 0.29 (57)	[6.90, 8.24]
Lab pH	--	7.75 ± 0.21 (52)	[7.25, 8.25]
Total organic carbon	ppb	519 ± 367[b] (62)	1,610[b]
Field conductivity	μmho/cm	344 ± 83 (22)	539
Lab conductivity	μmho/cm	332 ± 93 (36)	530
Total organic halogen	ppb	<20[b] (14)	37.6[b]
Total carbon	ppb	31,772 ± 7,022 (48)	50,100
Gross alpha	pCi/L	2.5 ± 1.5[b] (36)	5.79[b]
Gross beta	pCi/L	7.1 ± 2.6[b] (44)	12.62[b]
Radium	pCi/L	Not detected (10)	0.23

[a]Threshold value described in DOE-RL (1992). Generally represents maximum value.
[b]Potential outlier observation(s) were removed.
[c]From springs data (Early et al. 1986).
[d]From WHC (1990), based on inductively coupled plasma/mass spectrometer data.

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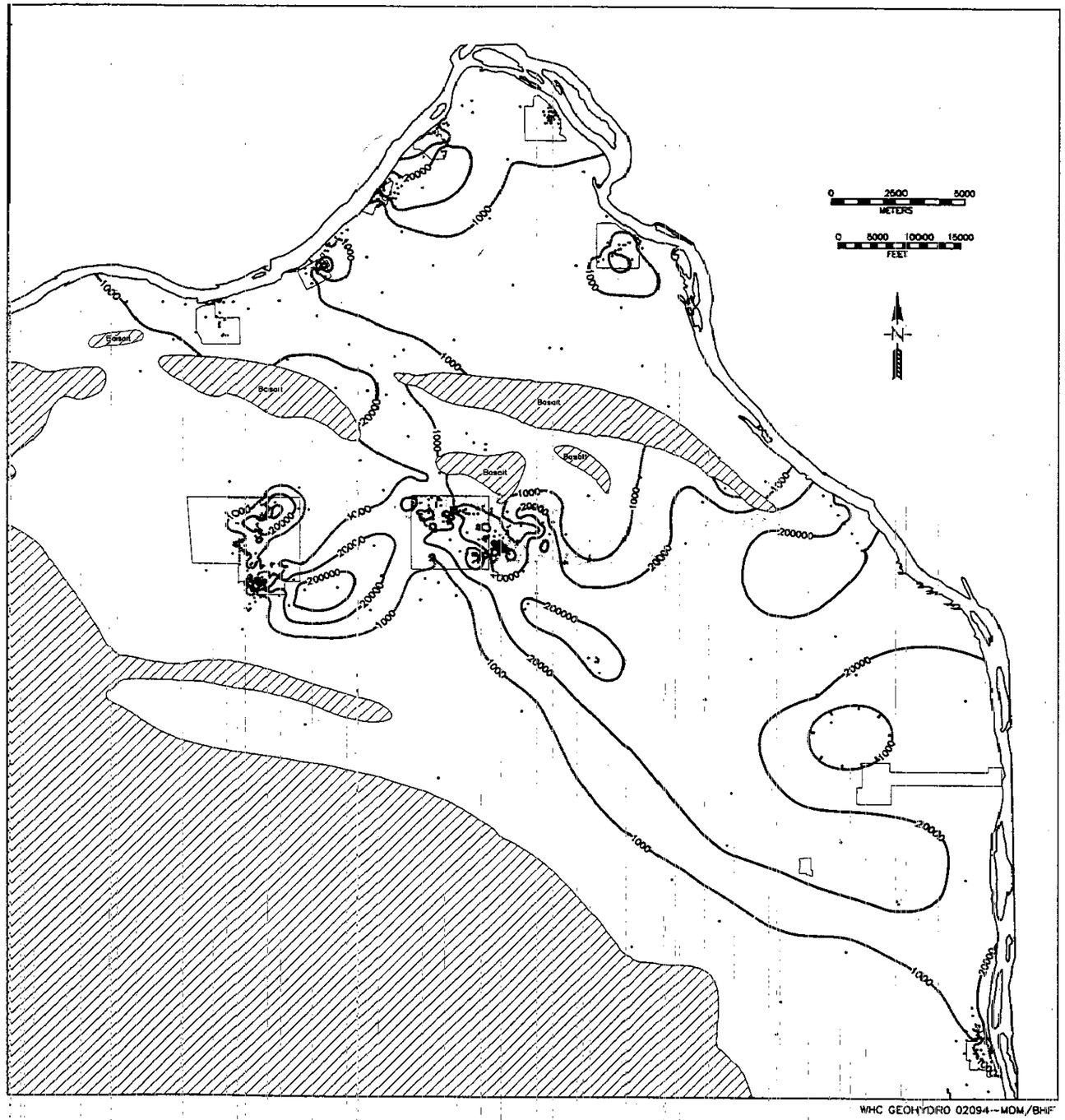
Figure 2-5. Tritium Distributio
the Uppermost Aquifer, Hanford S
January 1991 through September 1



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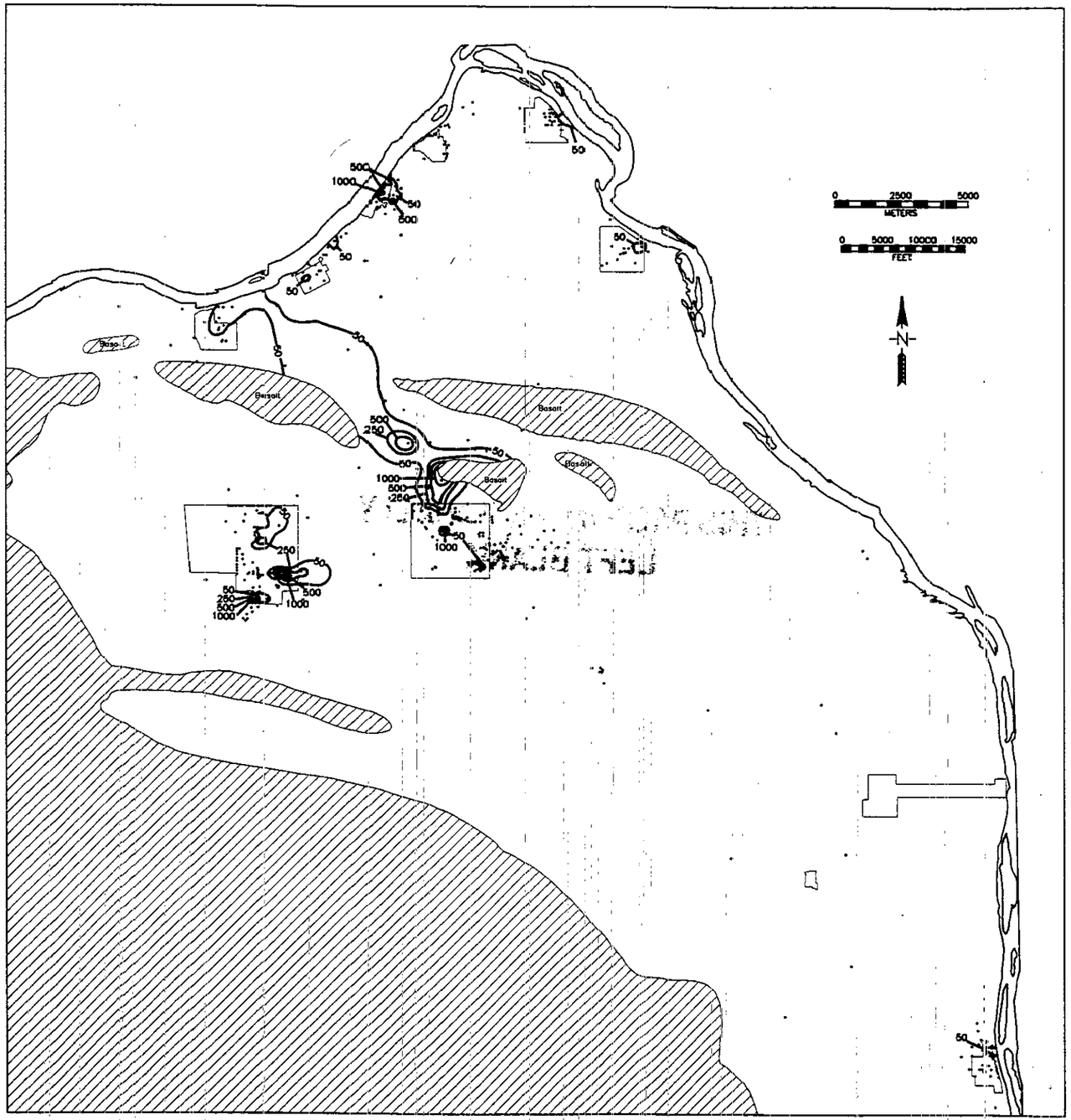

Figure 2-6. Gross Beta Distribution in the Uppermost Aquifer, Hanford Site January 1991 through September 1993

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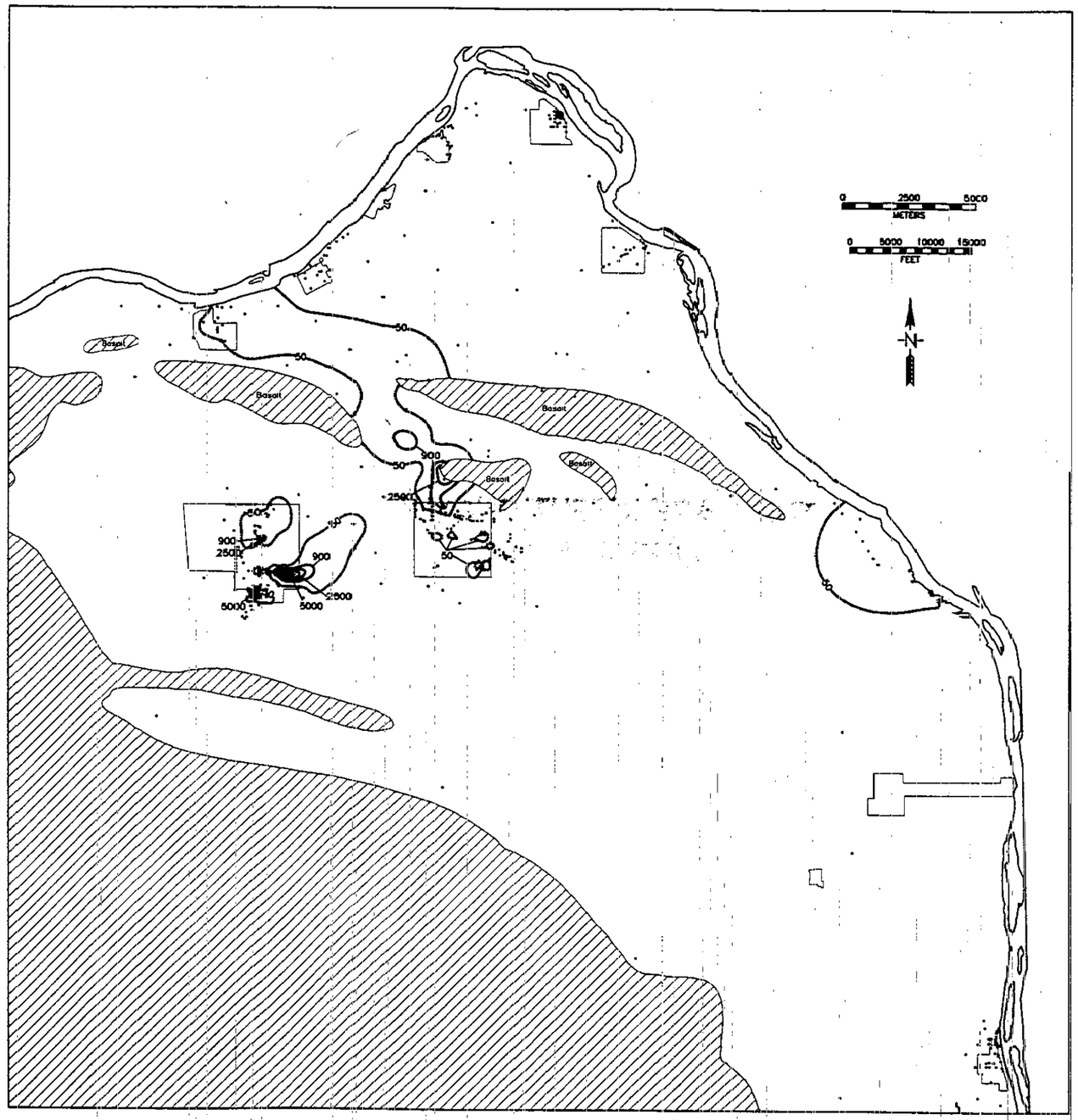
Figure 2-7. Technetium-99 Distri
in the Uppermost Aquifer, Hanford
January 1991 through September 19



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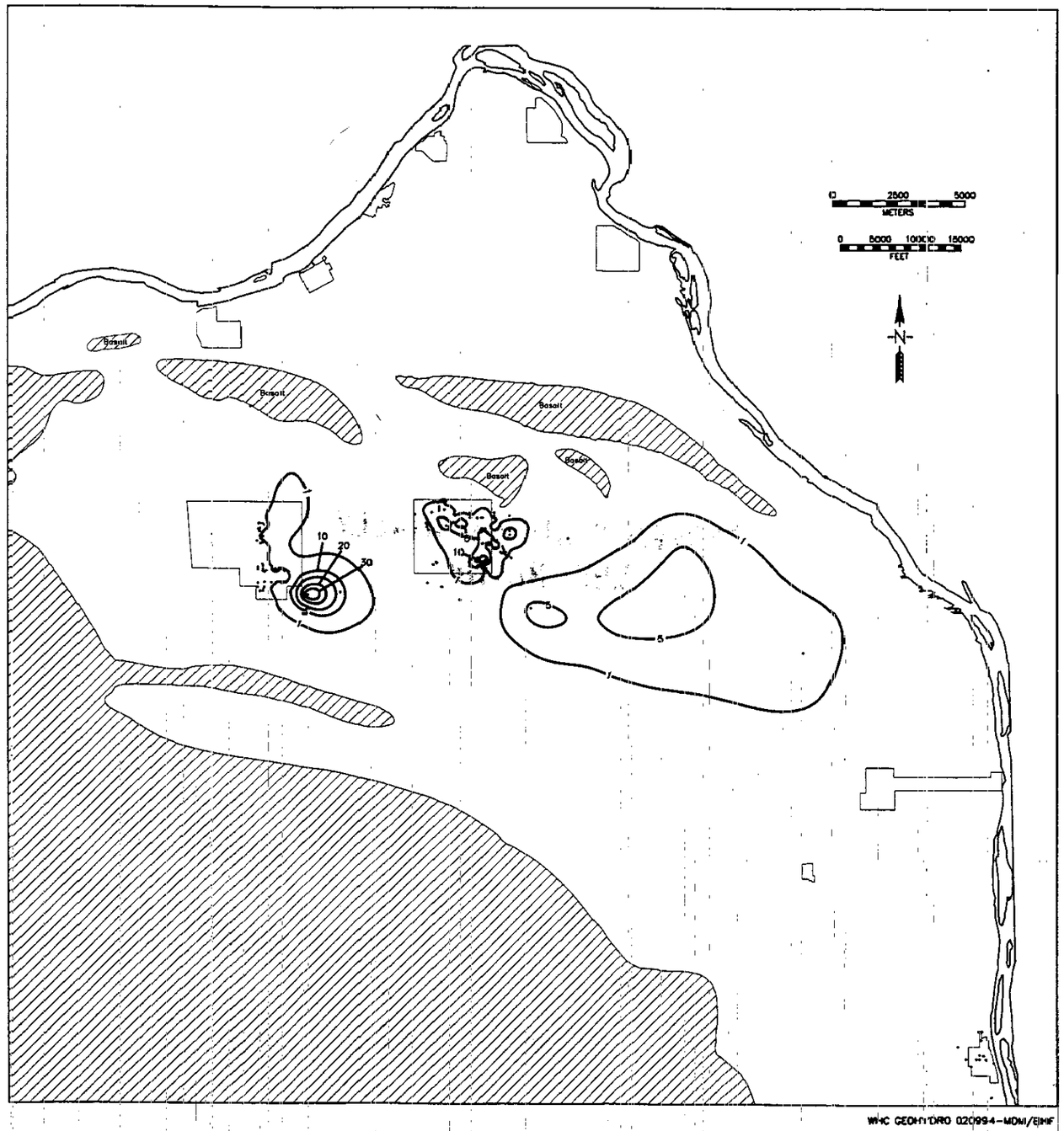

Figure 2-8. Iodine-129 Distributio the Uppermost Aquifer, Hanford Site January 1991 through September 1993

Hanford Site
Iodine–129
Groundwater Plume Map

• Well Location

1 Concentration Isopleth

This map was constructed from average values for the period 1/1/91 – 10/1/93, with anomalous data points removed.

Detection Limit	1 pCi/L
Drinking Water Standard	.1 pCi/L
Maximum Concentration Limit	.1 pCi/L
Washington Water Quality Standard	N/A
1/25 Derived Concentration Guide	.20 pCi/L

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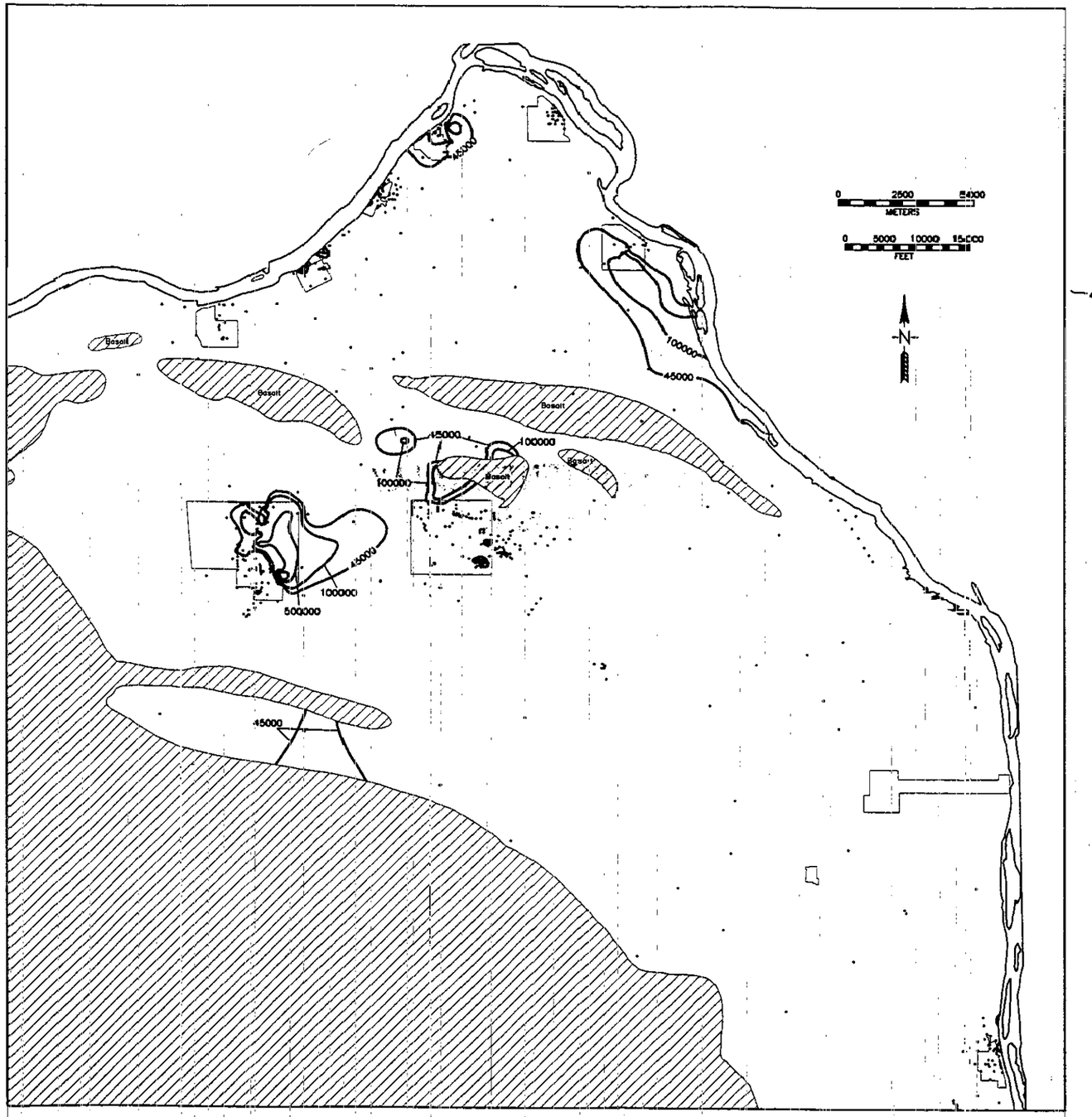

Figure 2-9. Nitrate Distribution in the Uppermost Aquifer, Hanford Site January 1991 through September 1993

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The concentrations of certain metals have been elevated in many unfiltered groundwater samples collected at the Hanford Site. The elevated metals are believed to be unrepresentative of groundwater quality. Filtered samples generally have much lower concentrations of metals. Iron, manganese, and chromium are especially common in unfiltered samples collected from newly constructed wells. These metals are constituents in steel well casing and screens and their presence in unfiltered samples is assumed to be due to particles of well materials. Elevated concentrations of aluminum have also been observed in some unfiltered samples, often associated with high-turbidity values. This suggests that clay- and silt-sized particles, including clay minerals (aluminosilicates), are being pumped and/or bailed when the well is sampled.

2.3 REFERENCES

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3.0 100 AREAS

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3.1 HYDROLOGIC SETTING OF THE 100 AREAS

The area north of Gable Mountain and Gable Butte and south of the Columbia River is known as the 100 Areas. The region includes the six decommissioned reactor areas.

3.1.1 Geology of the 100 Areas

Information in this section is derived mainly from Lindsey (1992) and Delaney et al. (1991). Details on the geology of each reactor area are available in the following documents:

- 100-B/C: Lindberg (1993a)
- 100-K: Lindberg (1993b)
- 100-N: Hartman and Lindsey (1993)
- 100-D, 100-H: Lindsey and Jaeger (1993)
- 100-F: Raidl (1994).

All of the reactor areas, except the 100-B/C Area, are located on the north limb of the Wahluke syncline. The 100-B/C Area lies approximately on the axis of the syncline. The suprabasalt sediments in the 100 Areas comprise the Ringold Formation, Hanford formation, and Holocene surficial deposits. The Ringold Formation shows significant stratigraphic variation across the 100 Areas (Figure 3.1-1). Gravel-dominated intervals generally are more abundant and thicker in the western part of the Wahluke syncline. These gravels pinch out to the north, up dip on the north limb of the syncline. The uppermost Ringold Formation is dominated by gravels in the west and muds (clay and silt-sized particles) in the east.

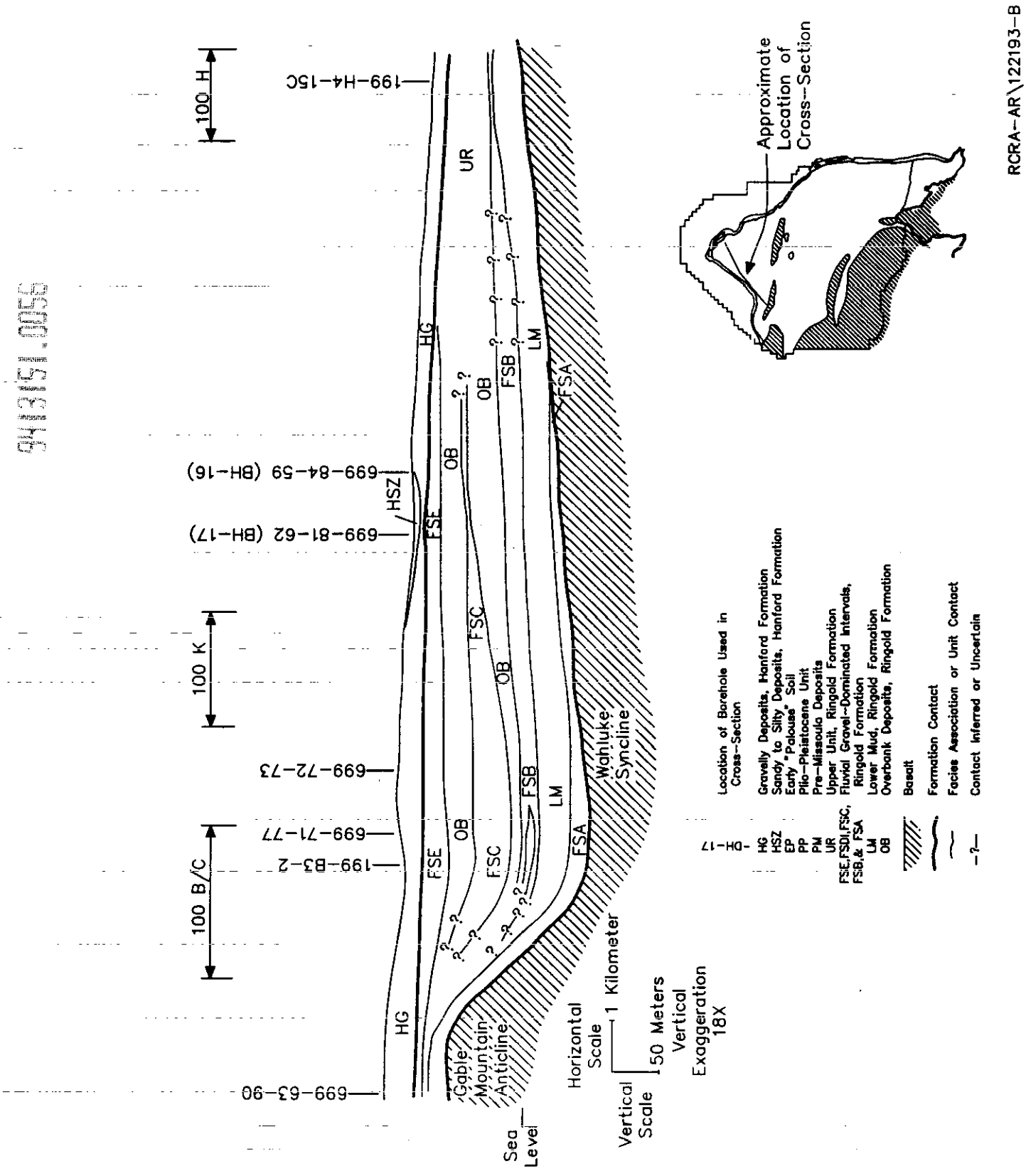
Ringold unit A (see Section 2.1) lies atop the Columbia River Basalt throughout much of the 100 Areas. The unit is a fluvial gravel, consisting of interbedded sand and cobbles with some caliche. It has been observed as ranging from 5.5 to 20 m (18 to 65 ft) thick. Unit A is not present in the 100-H or 100-F Areas; it is not known where the unit pinches out between the 100-N and 100-H Areas.

The lower mud unit, which overlies unit A, appears to be continuous beneath the 100 Areas. It is up to 43 m (140 ft) thick.

The gravel-dominated Ringold unit B overlies the lower mud unit beneath the 100 Areas. It is 3 to 22 m (10 to 72 ft) thick and coarsens from interbedded fluvial sand and overbank deposits in the west near the 100-B/C Area to interbedded fluvial sand and gravel in the east near the 100-F Area. It is absent in the 100-H Area.

An interval of overbank deposits overlies unit B throughout the 100 Areas.

Figure 3.1-1. Geologic Cross Section Across the 100 Areas (Delaney et al. 1991).



Fluvial gravel-dominated unit C is present in the western 100 Areas and pinches out to the northeast. Unit C is up to 35 m (115 ft) thick near the 100-B/C Area; it is absent on the north limb of the Wahluke syncline north of the 100-N and 100-F Areas. The unit grows thinner and finer south of 100-F Area, where it consists of 15 to 18 m (50 to 60 ft) of fluvial sand.

Another interval of overbank deposits overlies unit C. Thin fluvial sands are present within the interval.

The shallowest, fluvial gravel-dominated interval in the Ringold Formation beneath the 100 Areas is unit E. It is up to 30 m (100 ft) thick in the western Wahluke syncline near the 100-B/C Area and pinches out north of the 100-D Area and east of Gable Gap.

Near the 100-H and 100-F Areas, where unit E is absent, a unit of interbedded fluvial sands and overbank deposits is present. This unit grades into the overbank deposits overlying unit C. North of the 100-N and 100-F Areas, fluvial sands pinch out and overbank deposits dominate all the way down to unit B.

The post-Ringold, pre-Hanford deposits described in Section 2.1 are not present beneath the 100 Areas. The Hanford formation in the 100 Areas is dominated by pebble to cobble gravels. Clast size is largest in the 100-N Area and further west, where boulders up to 2 m (6 ft) in diameter are common. Hanford gravels elsewhere in the 100 Areas comprise pebbles and cobbles up to 0.3 m (1 ft) in diameter.

Holocene sediments in the 100 Areas are dominated by Columbia River and eolian deposits. The river deposits comprise gravels and coarse-grained sand deposited in channels, and overbank silts and fine sands. Eolian sediments consist of thin, fine, silty sands to dune sands.

3.1.2 Hydrogeologic Units in the 100 Areas

Information on the hydrology of the 100 Areas is available in Hartman and Peterson (1992) and Delaney et al. (1991).

The suprabasalt sediments beneath the 100 Areas form a series of aquifers and aquitards. In general, the gravel-dominated Ringold units (A, B, C, and E) and the Hanford formation (where saturated) act as aquifers. The finer-grained overbank deposits act as aquitards (see Figure 3.1-1).

The vadose zone beneath the 100 Areas comprises mainly the sands and gravels of the Hanford formation. In some areas, the top of Ringold Formation unit E is also unsaturated. The vadose zone in the 100 Areas is up to 40 m (130 ft) thick.

The uppermost aquifer is thickest near the 100-B/C Area (approximately 30 m [100 ft]) and thinnest in the 100-D, 100-H, and 100-F Areas (3 to 9 m [10 to 30 ft]). It consists of Ringold unit E or the Hanford formation. Figure 3.1-2 shows the geology at the water table. The aquifer is entirely within Ringold unit E in the 100-K, 100-N, and 100-D Areas. The bulk of the aquifer is in unit E in the 100-B/C Area, although the water table is in the

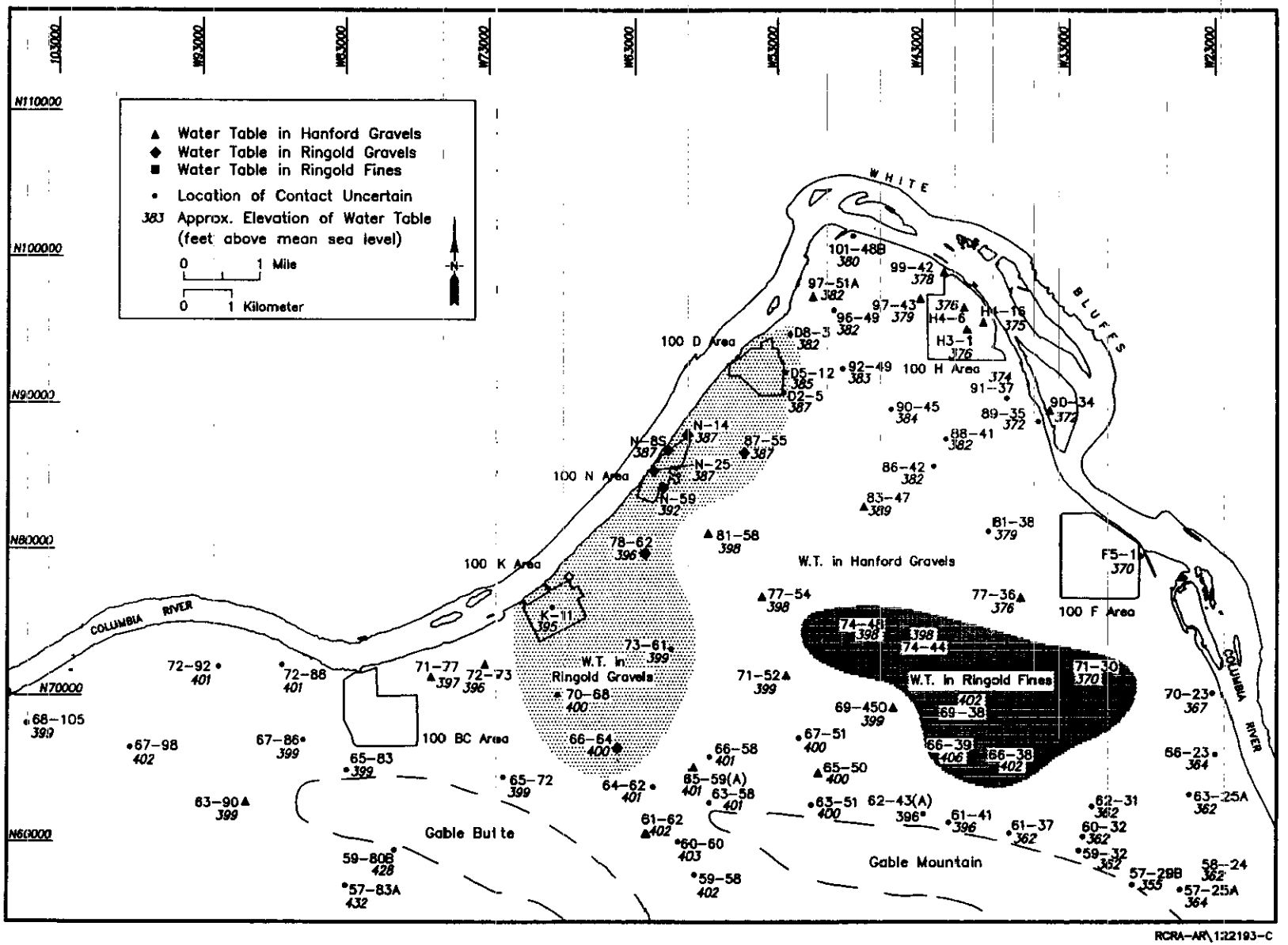


Figure 3.1-2. Geology at the Water Table in the 100 Areas (modified from Lindsey 1992).

Hanford formation. The uppermost aquifer is entirely within the Hanford gravels in the 100-H and 100-F Areas, where Ringold gravels are absent. The water table is in fine-grained units of the Ringold, in an area north of Gable Mountain.

Hydraulic conductivity estimates from various 100 Areas tests were compiled by Hartman and Peterson (1992). Horizontal hydraulic conductivity of the Hanford formation generally ranges in the hundreds to thousands of meters (feet) per day. Hydraulic conductivity of the uppermost Ringold aquifer ranges from tens to hundreds of meters (feet) per day.

The base of the uppermost aquifer is believed to be the fine-grained overbank and lacustrine deposits of the Ringold Formation. Sand- and gravel-dominated units deeper in the Ringold Formation are believed to act as confined aquifers. However, few wells are completed within these units, so the degree of isolation of the underlying aquifers is not well known. The overbank intervals contain thin layers of fine sand that also may act as aquifers.

3.1.3 Groundwater Flow in the 100 Areas

Water levels are measured in June and December each year throughout the Hanford Site, including the 100 Areas. Figure 3.1-3 is a water table map of the 100 Areas, constructed from data collected in June 1993. Groundwater is inferred to flow to the north and east through the area. In the 100-K, 100-N, and 100-D Areas, groundwater adjacent to the river flows to the northwest. Groundwater discharges from the uppermost aquifer to the Columbia River throughout most of the 100 Areas. West of the 100-B/C Area the gradient is extremely low and the direction of groundwater flow is somewhat variable; in June 1993 the river appears to recharge the aquifer. Other sources of recharge to the uppermost aquifer in the 100 Areas include infiltration of precipitation west of the Hanford Site; inflow of groundwater from the 200 Areas; and artificial recharge from Hanford Site operations in the 100-K, 100-N, and 100-D Areas.

River stage is measured with pressure transducers and data loggers in the 100-B/C, 100-N, 100-H, and 100-F Areas. Figure 2-3, in Chapter 2.0, illustrates average weekly river stage in the 100-B/C, 100-H, and 100-F Areas from October 1992 through September 1993. River stage was lowest in March and April, and highest in May. When river stage is high for several weeks or months (as is common in the spring), a reversed gradient forms near the river. Water can flow from the river into the aquifer during those times.

Segments of basalt above the water table in Umtanum Ridge, Gable Butte, and Gable Mountain affect groundwater flow into the 100 Areas. An elevated water table in the 200 Areas has increased the northward component of flow through gaps in the chain of basalt. Groundwater appears to "dam up" behind Gable Butte and Umtanum Ridge. The area of high groundwater north of Gable Mountain may be an expression of perched water or a remnant of a previously elevated water table from pre-Hanford irrigation. The water table in this area is within fine-grained Ringold sediments (see Section 3.1.2). An abrupt change in transmissivity of the aquifer near the east end of Gable Mountain is believed to cause the steep gradient there.

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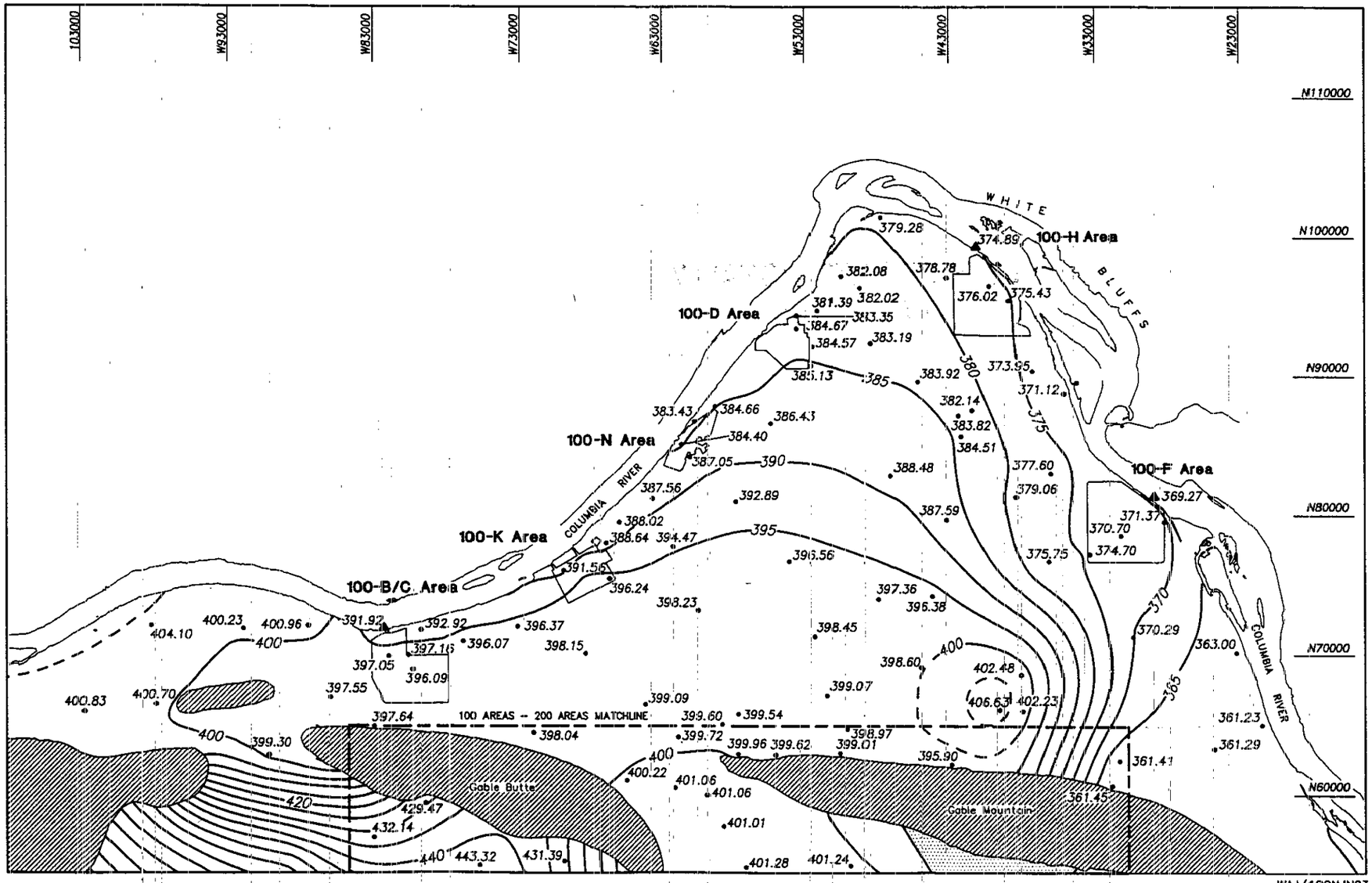
Figure 3.1-3. 100 Areas Water Table Map, June 1993.



100 Areas Water Table Map June 1993

382.51 ▲ Average river elevation (feet above mean sea level)

388.60 • Water table elevation, (feet above mean sea level)

400 Water table elevation Contour Interval = 5 ft

Areas where the basalt surface is generally above the water table

Area of conflicting data

The 100 Areas water table map has been prepared by the Geohydrologic Engineering Function, Westinghouse Hanford Company.

Note: To convert to metric, multiply elevation (ft) by 0.3048 to obtain elevation (m).

0 1 Mile

0 Kilometer

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3.1.4 Groundwater Chemistry in the 100 Areas

Groundwater chemistry in the uppermost aquifer in the 100 Areas has been affected by operations in the reactor areas and, to some extent, by an influx of contaminated water from the 200 Areas flowing northward between Gable Mountain and Gable Butte. The most prevalent contaminants are tritium, gross beta activity, nitrate, and chromium.

The following paragraphs reference maps of contaminant distribution in the uppermost aquifer of the Hanford Site. The maps were constructed from data collected between January 1991 and September 1993 from shallow wells. Anomalous data points were removed and values were averaged where more than one result existed.

Tritium was present in liquid effluent discharged at most of the reactor areas in the past (Figure 3.1-4). Tritium is not sorbed to sediments and moves unimpeded with groundwater flow, although it decays with time during transport. Currently the highest tritium activities are observed in the 100-K Area (up to 3 million pCi/L) but these levels are only seen in one well. Tritium activities greater than the drinking water standard of 20,000 pCi/L are also observed in the 100-N Area and in a small portion of the 100-F Area.

Elevated tritium activities are observed in wells across the horn of the Hanford Site between the 100-N, 100-D, and 100-H Areas. This area is interpreted in Figure 3.1-4 as a continuous plume with a tritium "high" originating in the 100-N Area. Groundwater mounds were present when tritium-laden effluent was being disposed, altering groundwater flow enough to push some of the tritium away from the river, potentially across the horn.

Tritium is also elevated between Gable Mountain and Gable Butte. The source of contamination is believed to be the 200 Areas. The presence of elevated tritium in other wells between Gable Butte, the 100-B/C Area, and 100-K Area suggest that the plume is migrating to the northwest, where it has merged with plumes from effluent disposal in the reactor areas.

Gross beta activity in groundwater is greater than the drinking water standard (50 pCi/L) in the 100-B/C, 100-N, 100-H, and 100-F Areas (Figure 3.1-5). The highest activities are in the 100-N Area, but levels are decreasing since the disposal facility ceased operation in 1991. Elevated gross beta activity is also observed between Gable Mountain and Gable Butte.

The elevated gross beta activity in the reactor areas is primarily caused by ^{90}Sr, which is greater than the drinking water standard (8 pCi/L) in at least a few wells in all of the reactor areas (Figure 3.1-6). The highest values of ^{90}Sr are in the 100-N Area. Technetium-99 accounts for the elevated gross beta plume flowing through Gable Gap (see Figure 2-7).

Nitrate is also a widespread contaminant in the 100 Areas groundwater, and it moves at nearly the same rate as groundwater. Its concentration is greater than the drinking water standard (45,000 ppb) in most of the reactor areas (Figure 3.1-7). The highest nitrate levels and the most widespread plumes are in the 100-D and 100-F Areas. The nitrate plume originating in the 100-F Area appears to be flowing toward the south-southwest, between Gable Mountain and the Columbia River.

Chromium is elevated in the 100-K, 100-D, and 100-H Areas (Figure 3.1-8). When chromium is dissolved in groundwater it is assumed to be Cr^{6+}, because other species of chromium are virtually insoluble in water. Hexavalent chromium is mobile in groundwater.

3.1.5 References

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Figure 3.1-4. Trittum Activity in the Uppermost Aquifer, 100 Areas, January 1991 through September 1993

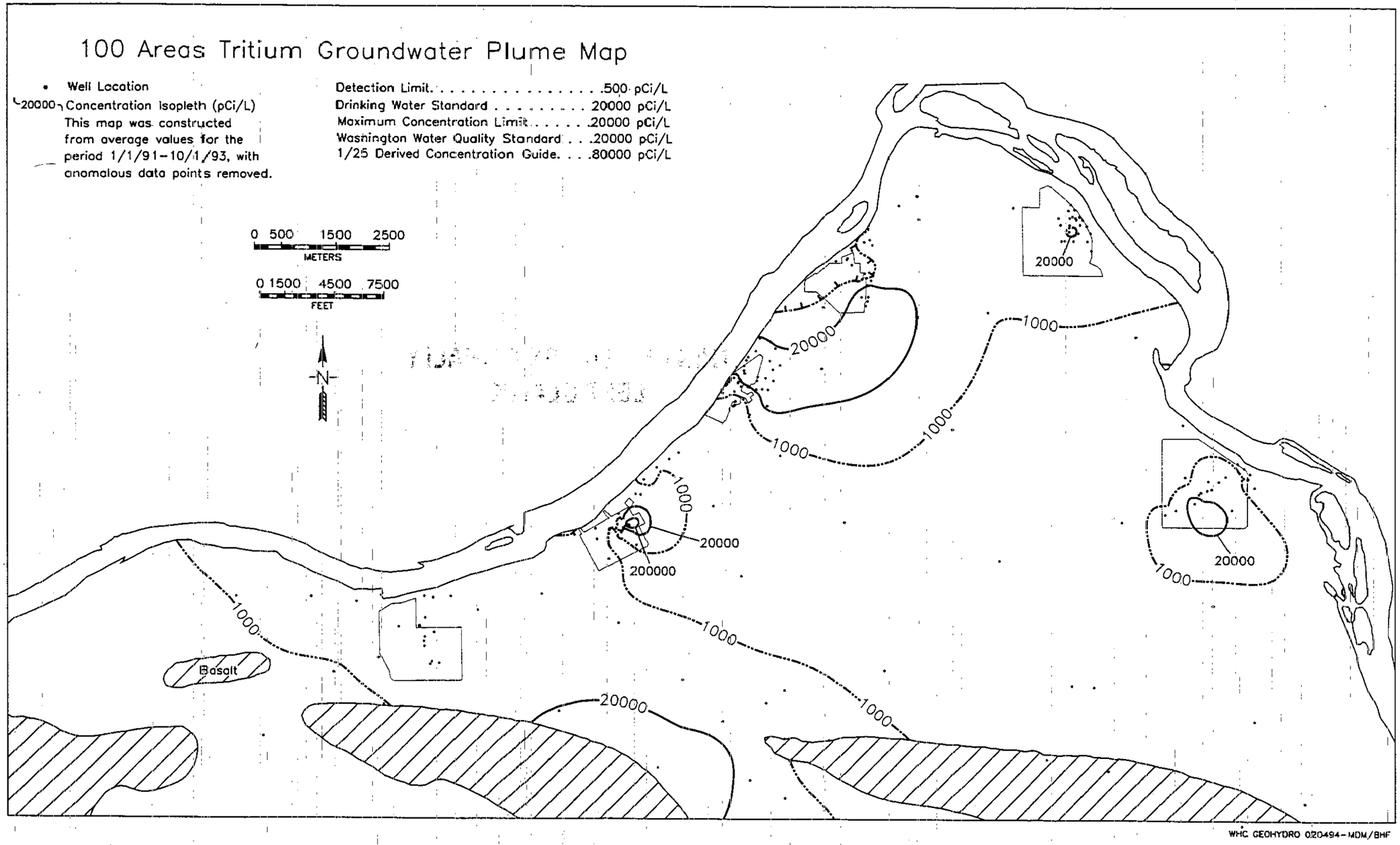

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Figure 3.1-5. Gross Beta Activity in the Uppermost Aquifer, 100 Area January 1991 through September 199

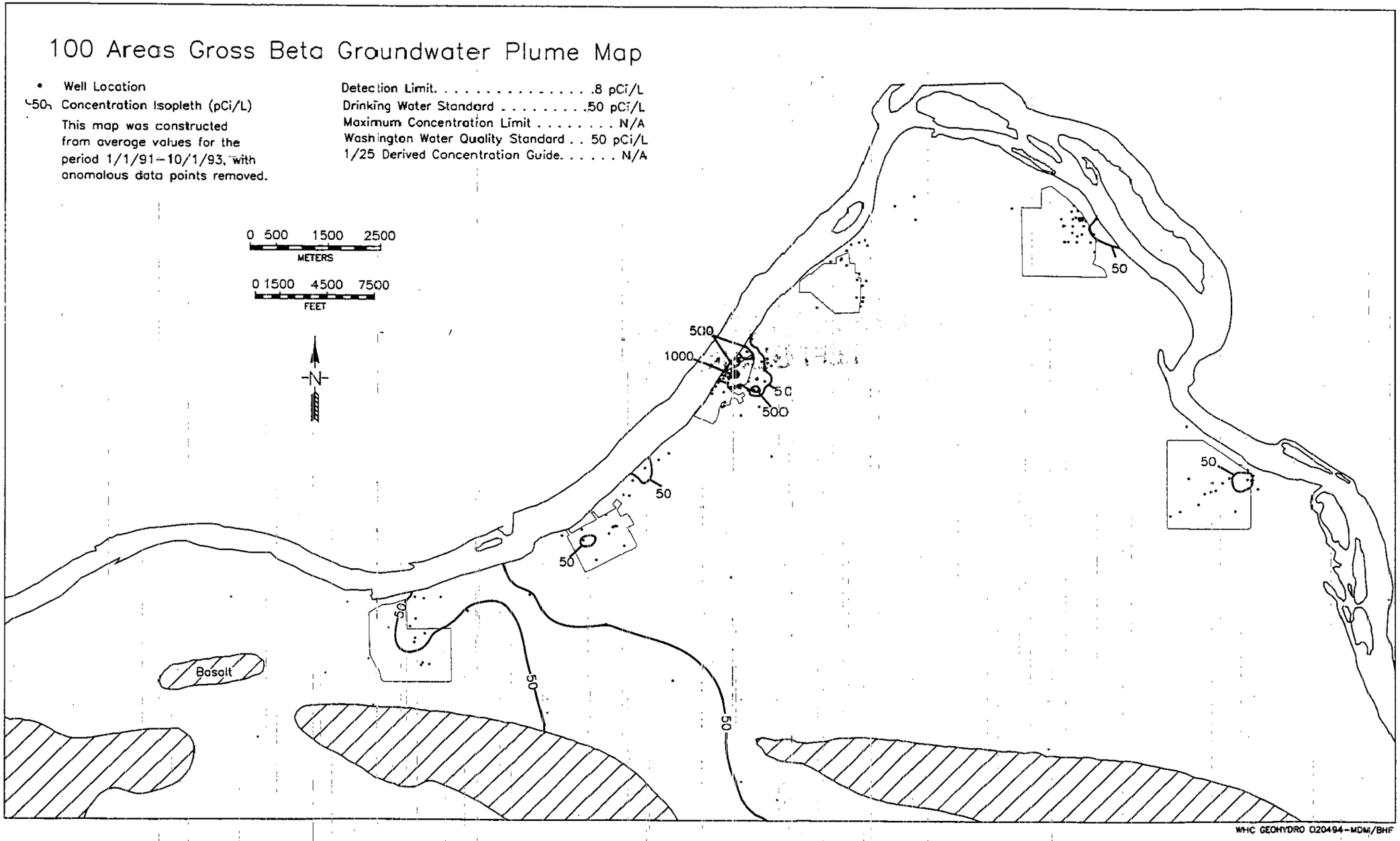

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Figure 3.1-6. Strontium-90 Activity in the Uppermost Aquifer, 100 Areas, January 1991 through September 1993.

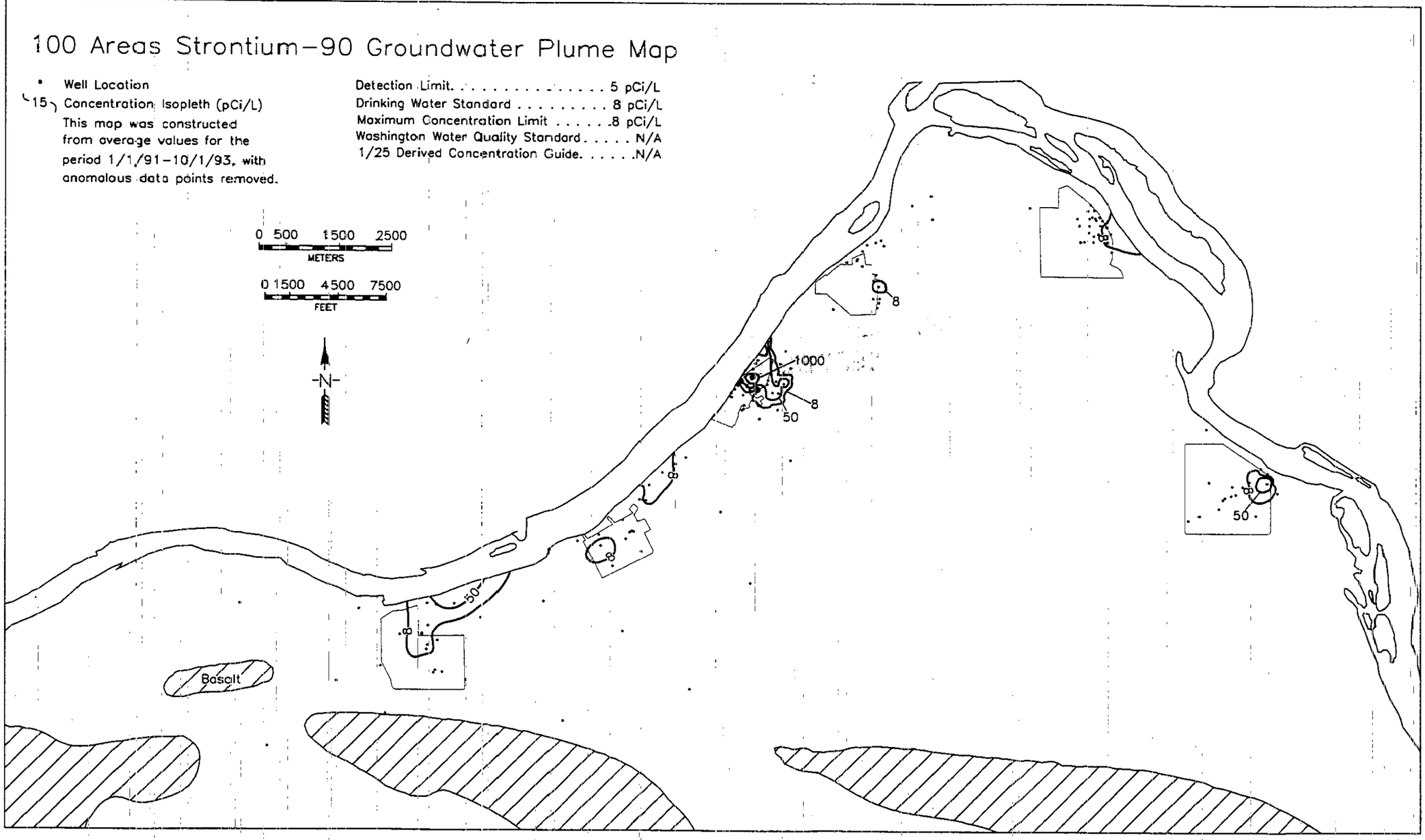

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Figure 3.1-7. Nitrate Activity in the Uppermost Aquifer, 100 Areas, January 1991 through September 1993

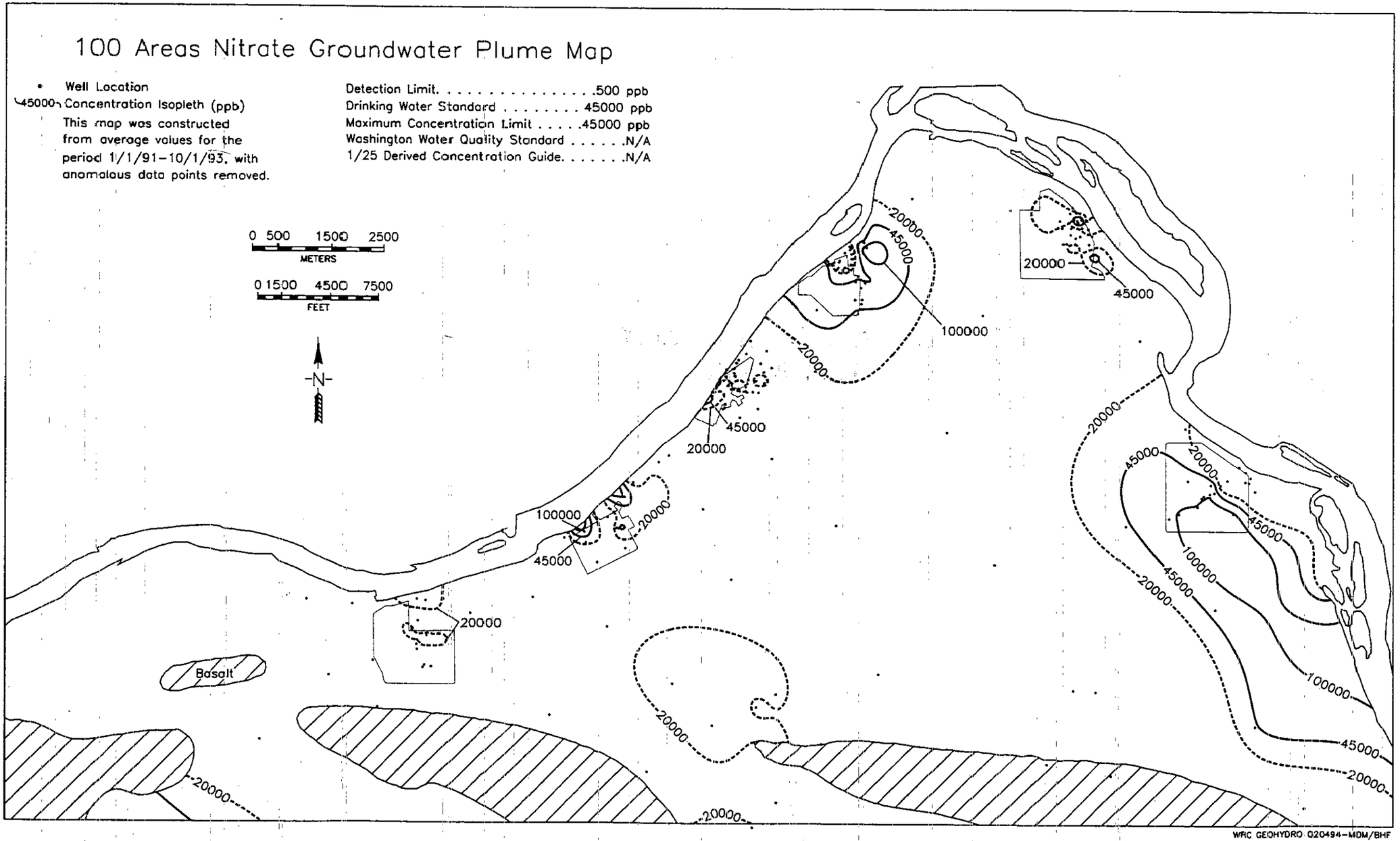

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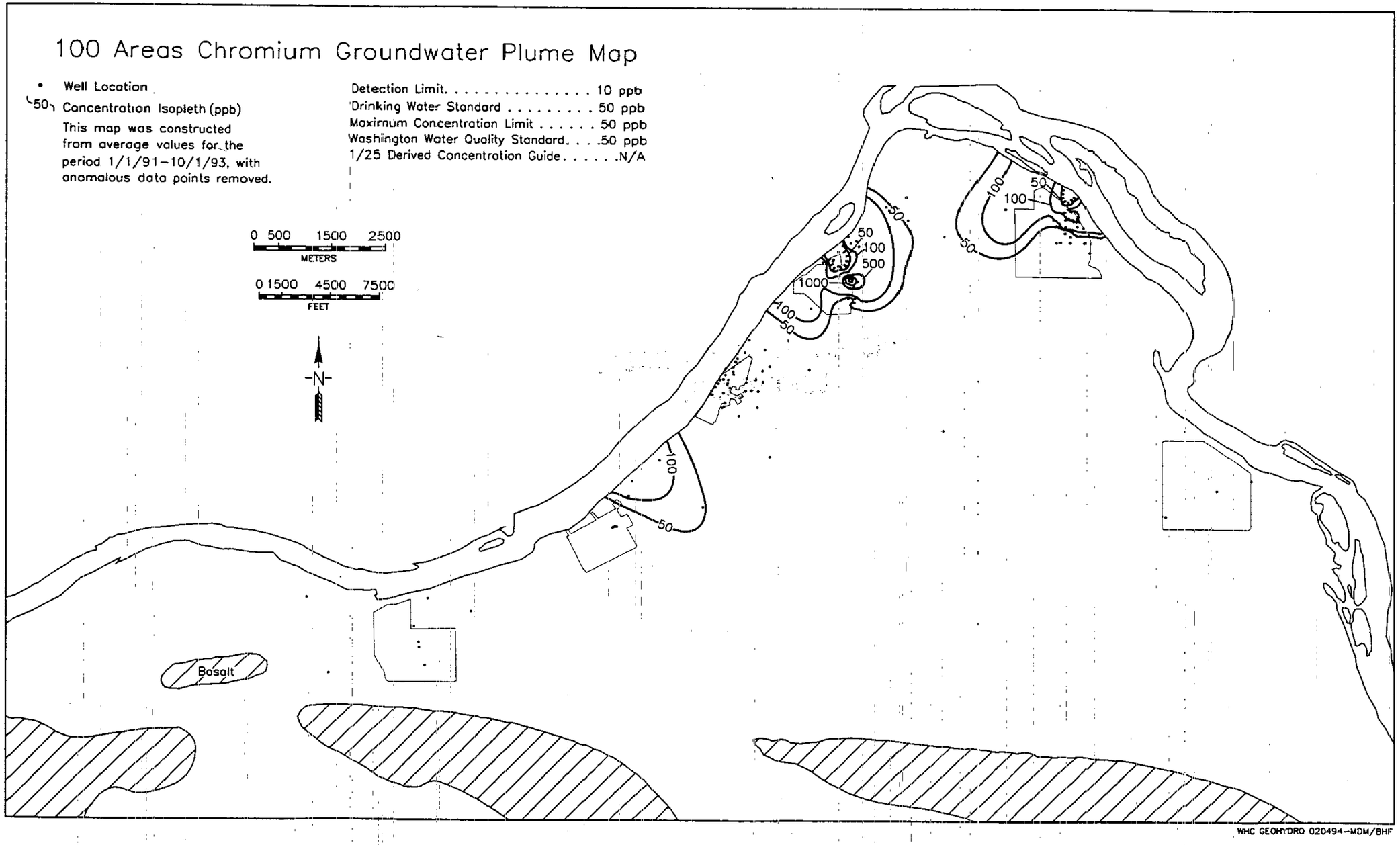
Figure 3.1-8. Chromium Activity i
the Uppermost Aquifer, 100 Areas,
January 1991 through September 199



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3.2 100-N AREA RESOURCE CONSERVATION AND RECOVERY ACT SITES

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Four *Resource Conservation and Recovery Act of 1976* (RCRA) units are located in the 100-N Area: (1) the 1301-N Liquid Waste Disposal Facility (LWDF), (2) the 1324-N Surface Impoundment, (3) the 1324-NA Percolation Pond, and (4) the 1325-N LWDF (Figure 3.2-1). The 1324-N and 1324-NA units are monitored as a single site. Interim-status groundwater monitoring began at all of the sites in December 1987. The sites are located close together and have related effects on the groundwater hydrology of the 100-N Area. Therefore, they are discussed in a single section of this report.

The 1301-N and 1325-N LWDFs are monitored under indicator evaluation programs, as described in the groundwater monitoring plan (Hartman 1993e). The 1324-N/NA site is monitored under a groundwater quality assessment program, as described in the assessment plan (Hartman 1993f).

3.2.1 Facility Overview

The 1301-N LWDF was the primary liquid waste disposal facility for the N Reactor from 1963 until 1985. Discharges to the 1301-N LWDF were primarily radioactive fission and activation products. Minor amounts of dangerous waste also were discharged, including the following: (1) hydrazine, (2) ammonium hydroxide, (3) diethylthiourea, (4) sodium dichromate, (5) morpholine, (6) phosphoric acid, (7) lead, and (8) cadmium. The 1301-N LWDF consists of a concrete basin with an unlined, zig-zagging extension trench, covered with concrete panels.

The 1325-N LWDF was constructed in 1983, and N Reactor effluent was discharged to it and to the 1301-N LWDF. In 1985, discharge to the 1301-N LWDF ceased, and all effluent was sent to the 1325-N LWDF. All discharge to the 1325-N LWDF ceased in late 1991. The 1325-N LWDF consists of a concrete basin with an unlined extension trench, covered with concrete panels.

The 1324-N Surface Impoundment was a treatment facility that was in service from May 1986 to November 1988. This facility is a double-lined pond that was used to neutralize high and low pH wastes from a demineralization plant. The 1324-NA Percolation Pond is an unlined pond that was used to treat wastes from August 1977 to May 1986, and to dispose of treated wastes from May 1986 to August 1990. The effluent to both facilities contained sulfuric acid and sodium hydroxide, and its pH was occasionally high or low enough to be classified as a dangerous waste.

The RCRA sites in the 100-N Area are part of the 100-NR-1 source operable unit, under the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) program. Groundwater is covered by the 100-NR-2 operable unit. Groundwater sampling and analysis are coordinated between the RCRA and CERCLA programs.

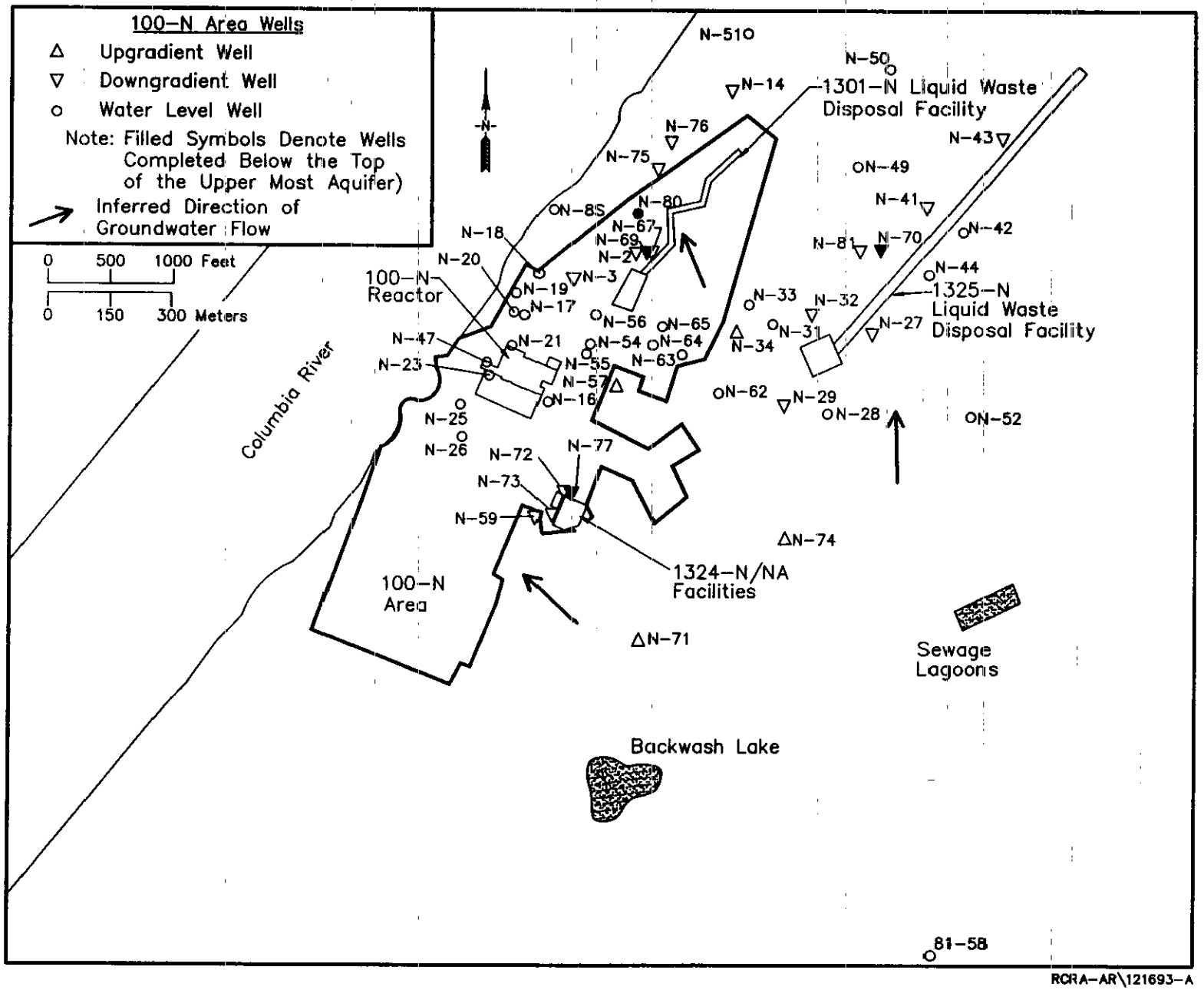

Figure 3.2-1. Locations of 100-N Area RCRA Sites and Groundwater Monitoring Wells.

Hartman and Lindsey (1993) describe the hydrogeology of the 100-N Area. Figure 3.2-2 is a geological cross section through the 100-N Area. The uppermost aquifer beneath the 100-N Area is a sand and gravel unit in the Ringold Formation. The base of the aquifer is believed to be a clay-rich unit approximately 12 m (40 ft) beneath the water table.

Hydraulic conductivity estimates for the uppermost aquifer are highly variable. Gilmore et al. (1992) used several methods to derive a more representative range. Horizontal hydraulic conductivity is estimated to range from 6.0 to 37 m/d (20 to 120 ft/d) beneath most of the area.

3.2.2 Summary of 1993 Activities

No liquid effluent was discharged to the 100-N RCRA units in 1993. The declining water levels evident in recent years appear to have stabilized in the past year. Seasonal fluctuations are evident, and the groundwater mounds formerly present beneath the area have dissipated.

An indicator evaluation monitoring program was reinstated at the 1301-N LWDF in March 1993. Wells were sampled quarterly to re-establish baseline levels of indicator parameters. The 1325-N LWDF remained in an indicator evaluation program and monitoring wells were sampled semiannually. Hartman (1993e) describes the groundwater monitoring programs for both of these sites.

The 1324-N/NA site has been in assessment monitoring since 1989. The assessment program was revised in 1993 to investigate the cause of elevated total organic halogen (TOX) in some of the downgradient wells (Hartman 1993f). The monitoring network was reduced from the original assessment network, and the constituent list was changed. The wells were sampled quarterly during the past year.

The first four quarters of monitoring at 1325-N upgradient well N-74[1] were completed in 1993. Background values of indicator parameters were re-established using data from the new upgradient well. One new well was installed for the 1325-N LWDF (N-81). The well was sampled for the first time in May 1993, and quarterly through the rest of the year. Water levels were measured monthly in most of the wells in the 100-N Area.

3.2.3 Other Activities in 1993

A report describing the hydrogeology of the 100-N Area was prepared to support CERCLA studies and RCRA closure plans (Hartman and Lindsey 1993). The report describes the geology, hydrology, and groundwater chemistry of the area, focusing on the shallow hydrologic units.

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[1]Well numbers are abbreviated in Section 3.2 by deleting prefix numbers. Wells in the 100-N Area (e.g., N-2, N-71, and N-81) have the prefix 199-. Wells in the 600 Area (e.g., 81-58) have the prefix 699-.

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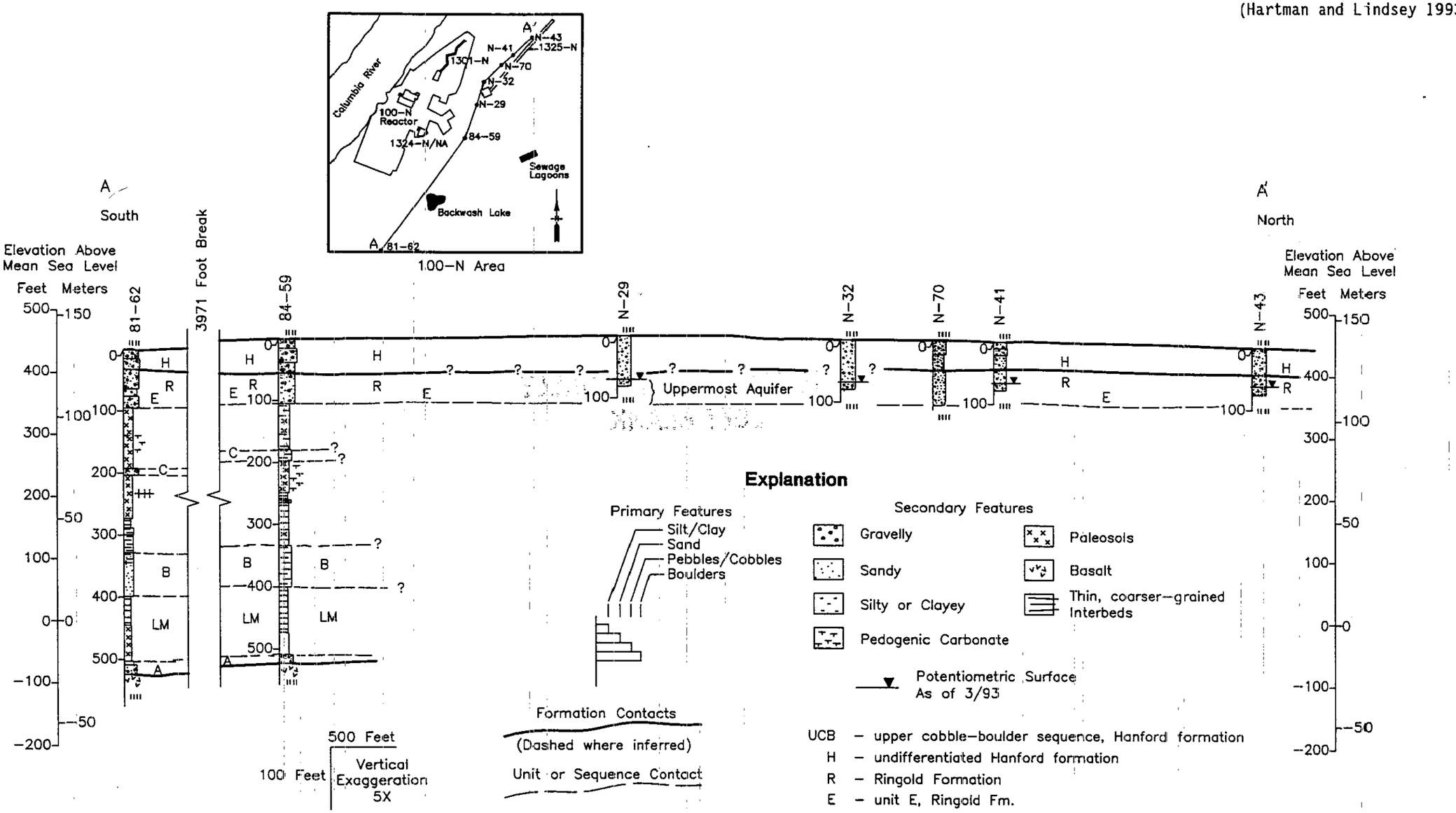
Figure 3.2-2. Geologic Cross Section, South to North Beneath the 100-N Area (Hartman and Lindsey 1993).



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Alexander and Johnson (1993) contains a groundwater impact assessment for the 1325-N LWDF. Flow and transport calculations suggest that natural recharge and water table fluctuations may cause migration of ^{90}Sr from the sediments into the aquifer.

3.2.4 Sampling and Analysis Program

Sampling and analysis for the 1301-N and 1325-N LWDFs are described by Hartman (1993e). Wells in the sampling networks are listed in Tables 3.2-1 and 3.2-2; constituents analyzed are listed in Table 3.2-3. Wells in the 1301-N network are sampled quarterly to re-establish background conditions. The 1325-N network is sampled semiannually, except for well N-81, a new well that is sampled quarterly. In August 1993 a revised assessment program for the 1324-N/NA site was implemented (Hartman 1993f). This program supersedes the previous assessment program (Gilmore 1989; Hartman 1991b). Wells formerly and currently sampled for 1324-N/NA assessment monitoring are listed in Table 3.2-4. The new constituent list is shown in Table 3.2-5. The 1324-N/NA network is sampled quarterly. Water levels were measured monthly in most of the wells in the 100-N Area during the past year. Well locations for the 100-N Area are shown in Figure 3.2-1.

Water levels and results of laboratory analyses of 100-N Area groundwater were reported in quarterly reports (Hartman 1993b, 1993c, 1993d, 1994).

3.2.5 Groundwater Chemistry: 1301-N and 1325-N LWDFs

This section describes results of chemical analyses of groundwater and defines the constituents of concern for the 1301-N and 1325-N LWDF sites. The sites are discussed together because their effluents were virtually identical and their contaminant plumes overlap.

3.2.5.1 Constituents of Concern: 1301-N and 1325-N LWDF. Groundwater monitoring at the 1301-N and 1325-N LWDFs provides no evidence that dangerous, nonradioactive constituents from the sites have entered the groundwater. The indicator parameters are specific conductance, pH, total organic carbon (TOC), and TOX (40 *Code of Federal Regulations* [CFR] 265.92[b][3]). Other analytes are monitored in groundwater to look for the dangerous waste constituents that were discharged to the 1301-N and 1325-N LWDFs during their use (see Section 3.2.1). These analytes include hydrazine, ammonium ion, nitrate, chromium, phosphate, lead, and cadmium. There were no significant detections of these analytes that could be attributed to the 1301-N or 1325-N LWDFs.

Hydrazine, phosphate, chromium, lead, and cadmium (in filtered samples) have not been detected in 1301-N or 1325-N groundwater in significant concentrations. Ammonium ion has been detected in several wells upgradient and downgradient of the 1301-N LWDF, but not consistently and at low concentrations (100 to 200 ppb). In 1987 ammonium ion in the 1325-N network was as high as 3,630 ppb in well N-29. Ammonium concentrations declined after 1989, and most were less than detection limits during the past year. Nitrate has been elevated in various parts of the 100-N Area in the past. Its current distribution does not suggest any single source (Figure 3.2-3). The highest concentration in the past year was 64 ppm, south of the N Reactor building.

Table 3.2-1. Wells Used to Monitor Groundwater Chemistry for the 1301-N Liquid Waste Disposal Facility.

Well	Aquifer	Sampling frequency	Well standard	Other networks
199-N-2[64]	Top of unconfined	Q	PRE	--
199-N-3[64]	Top of unconfined	Q	PRE	100-NR-2
199-N-14[69]	Top of unconfined	Q	PRE	--
199-N-34[83]	Top of unconfined	Q	PRE	--
199-N-57[87]	Top of unconfined	Q	RCRA	
199-N-67[88]	Top of unconfined	Q	RCRA	100-NR-2
199-N-69[88]	Bottom unconfined	Q	RCRA	--
199-N-75[92]	Top of unconfined	Q	RCRA	100-NR-2
199-N-76[92]	Top of unconfined	Q	RCRA	100-NR-2

Notes: Shading denotes upgradient wells. Superscript following well number denotes the year of installation.
PRE = well is not constructed to RCRA standards.
Q = frequency on a quarterly basis.
RCRA = well is constructed to RCRA standards.

Table 3.2-2. Wells Used to Monitor Groundwater Chemistry for the 1325-N Liquid Waste Disposal Facility.

Well	Aquifer	Sampling frequency	Well standard	Other networks
199-N-27[83a]	Top of unconfined	SA	PRE	--
199-N-29[83a]	Top of unconfined	SA	PRE	--
199-N-32[83]	Top of unconfined	SA	PRE	100-NR-2
199-N-41[84]	Top of unconfined	SA	PRE	--
199-N-43[84]	Top of unconfined	SA	PRE	--
199-N-70[88]	Bottom unconfined	SA	RCRA	100-NR-2
199-N-74[91]	Top of unconfined	SA	RCRA	100-NR-2
199-N-81[93]	Top of unconfined	Q	RCRA	--

Notes: Shading denotes upgradient well. Superscript following well number denotes the year of installation.

[a]Although wells N-27 and N-29 are currently upgradient of the 1325-N LWDF, they were downgradient when the facility was active. The groundwater chemistry at these wells is still affected by the facility, so they are monitored as downgradient wells.

PRE = well is not constructed to RCRA standards.
Q = frequency on a quarterly basis.
RCRA = well is constructed to RCRA standards.
SA = frequency on a semiannual basis.

Table 3.2-3. Constituent List for 1301-N and 1325-N LWDFs.

Contamination indicator parameters		
pH (field and lab)	Total organic carbon	
Specific conductance (field and lab)	Total organic halogen	
Groundwater quality parameters		
Chloride	Manganese	Sodium
Iron	Phenols	Sulfate
Drinking water parameters		
Arsenic	Gross alpha	Radium
Barium	Gross beta	Selenium[a]
Cadmium	Lead	Silver
Chromium	Mercury[a]	Turbidity
Coliform[a]	Nitrate	
Fluoride		
Site-specific parameters		
Gamma scan	Temperature (field)	
Hydrazine	Tritium	
Strontium-90		

[a]Only for new wells for the first four quarters of monitoring.

Table 3.2-4. Wells Used to Monitor Groundwater Chemistry for the 1324-N/NA Facilities.

Well	Aquifer	Sampling frequency	Well standard	Other networks
Monitored for assessment program before June 1993				
199-N-17[81]	Top of unconfined	Q	PRE	100-NR-2
199-N-21[81]	Top of unconfined	Q	PRE	100-NR-2
199-N-47[84]	Top of unconfined	Q	PRE	--
199-N-54[87]	Top of unconfined	Q	RCRA	100-NR-2
199-N-55[87]	Top of unconfined	Q	RCRA	--
199-N-56[87]	Top of unconfined	Q	RCRA	--
Monitored in previous and current assessment programs				
199-N-59[87]	Top of unconfined	Q	RCRA	--
199-N-71[91]	Top of unconfined	Q	RCRA	100-NR-2
199-N-72[91]	Top of unconfined	Q	RCRA	--
199-N-73[91]	Top of unconfined	Q	RCRA	100-NR-2
199-N-77[92]	Bottom of unconfined	Q	RCRA	100-NR-2

Notes: Shading denotes upgradient well. Superscript following well number denotes the year of installation.
PRE = well is not constructed to RCRA standards.
Q = frequency on a quarterly basis.
RCRA = well is constructed to RCRA standards.

Table 3.2-5. Constituent List for 1324-N/NA Assessment Monitoring.

Contamination indicator parameters		
pH (field and lab)	Total organic carbon	
Specific conductance (field and lab)	Total organic halogen	
Groundwater quality parameters		
Chloride	Manganese	Sodium
Iron	Phenols	Sulfate
Drinking water parameters		
Arsenic	Gross alpha	Radium
Barium	Gross beta	Selenium
Cadmium	Lead	Silver
Chromium	Mercury	Turbidity
Fluoride	Nitrate	
Site-specific parameters		
Temperature (field)	Volatile organics by gas chromatography	

While the 1301-N and 1325-N LWDFs were in use, they introduced radioactive constituents, primarily tritium and ^{90}Sr, to the groundwater. Figure 3.2-4 illustrates ^{90}Sr in the uppermost aquifer. Its distribution suggests that there are two separate plumes, one associated with the 1301-N LWDF and another associated with the 1325-N LWDF. The 1301-N LWDF was in service for over 20 years and the resulting ^{90}Sr plume is larger and has higher activities than the 1325-N plume.

Strontium-90 is not very mobile in groundwater. The shape and position of the plumes have not changed much since 1990 (Hartman 1991a, 1992a, 1993a). However, the activity at the center of the 1325-N plume has decreased (e.g., well N-29, Figure 3.2-5). Strontium-90 activity in wells downgradient of the 1301-N LWDF have increased slightly since 1990 (Figure 3.2-6).

Figure 3.2-7 shows tritium in the uppermost aquifer. The distribution of tritium suggests its source was the 1325-N LWDF, although the center of the plume has apparently migrated downgradient toward the 1301-N trench. Tritium-contaminated water from the 100-N Area appears to have migrated northward to the 100-D Area (see Figure 3.1-4 and Section 3.1.4). It also migrated to the south, toward what is now the upgradient well (N-74) for the 1325-N site.

Figure 3.2-3. Nitrate in the Uppermost Aquifer Beneath the 100-N Area, February/March 1993 (Hartman and Lindsey 1993).

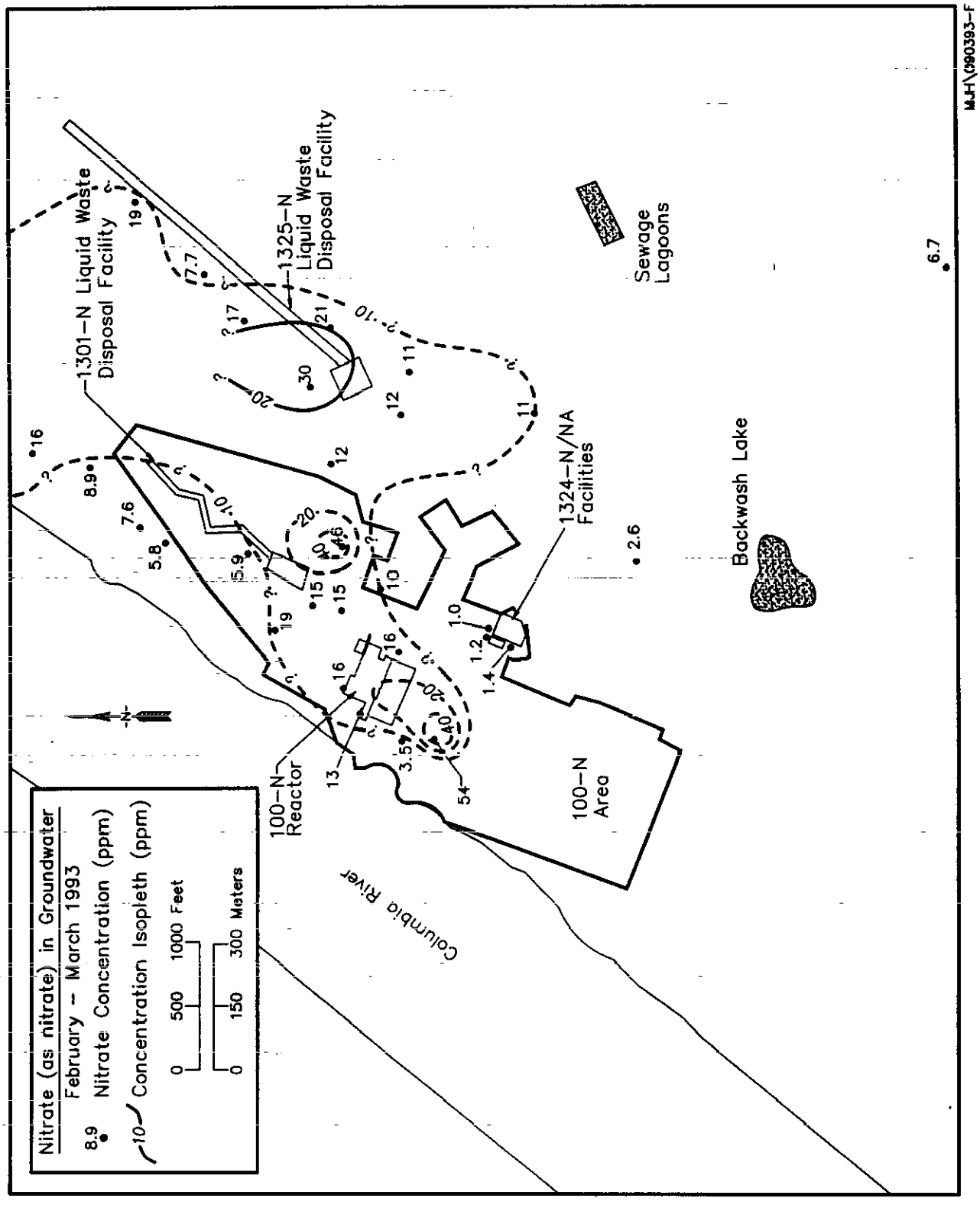


Figure 3.2-4. Strontium-90 in the Uppermost Aquifer Beneath the 100-N Area, February/March 1993 (Hartman and Lindsey 1993).

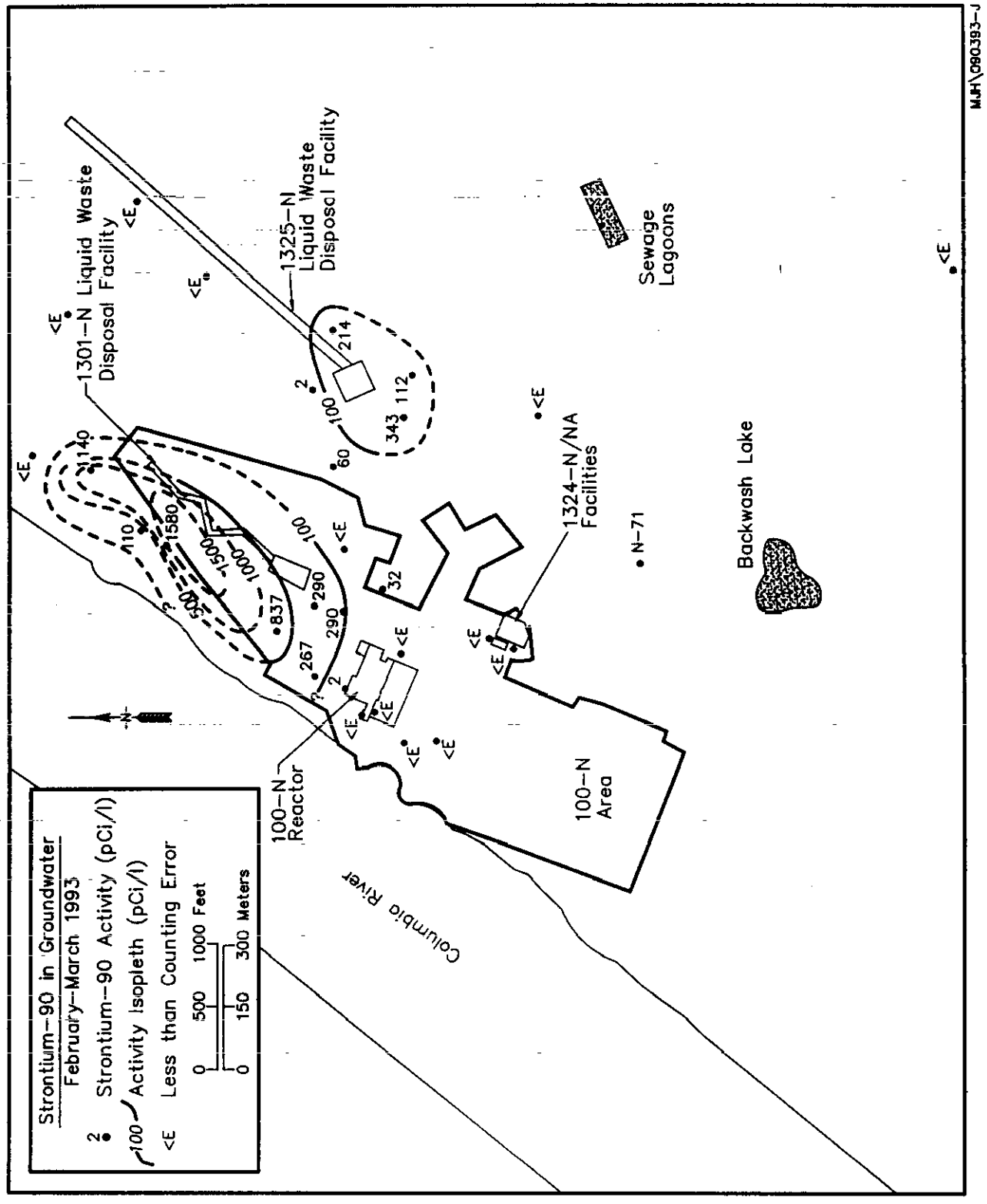


Figure 3.2-5. Strontium-90 Versus Time in Wells N-27 and N-29.

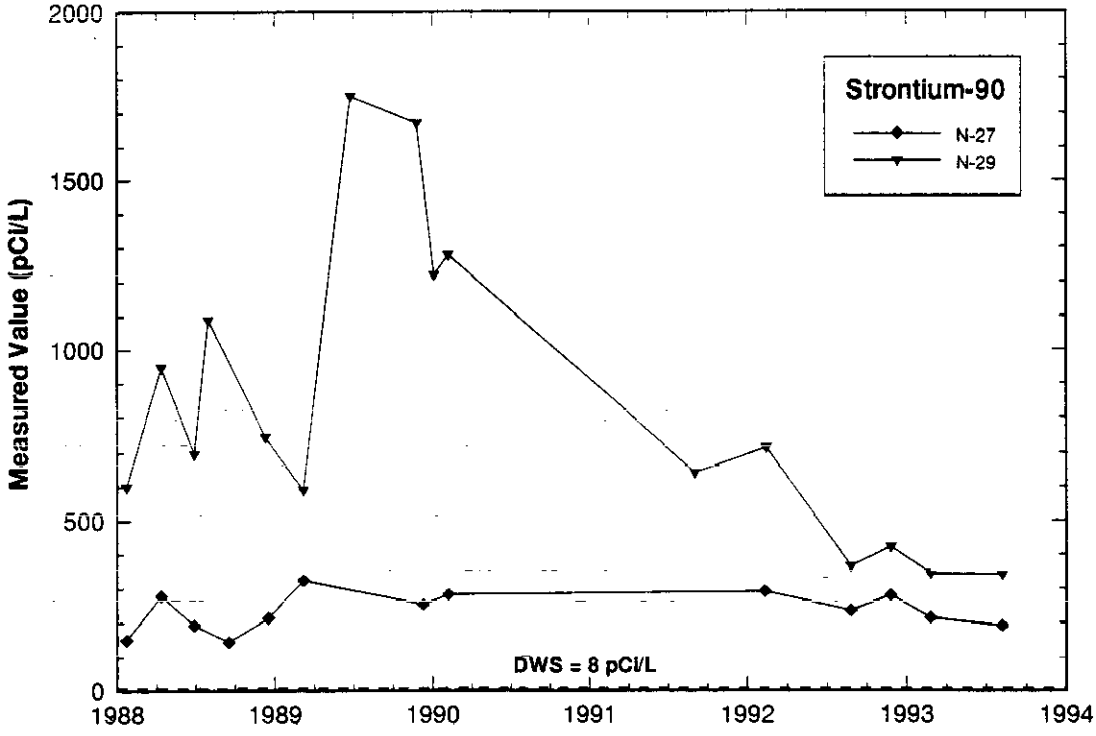


Figure 3.2-6. Strontium-90 Versus Time in Wells N-14, N-57, and N-75.

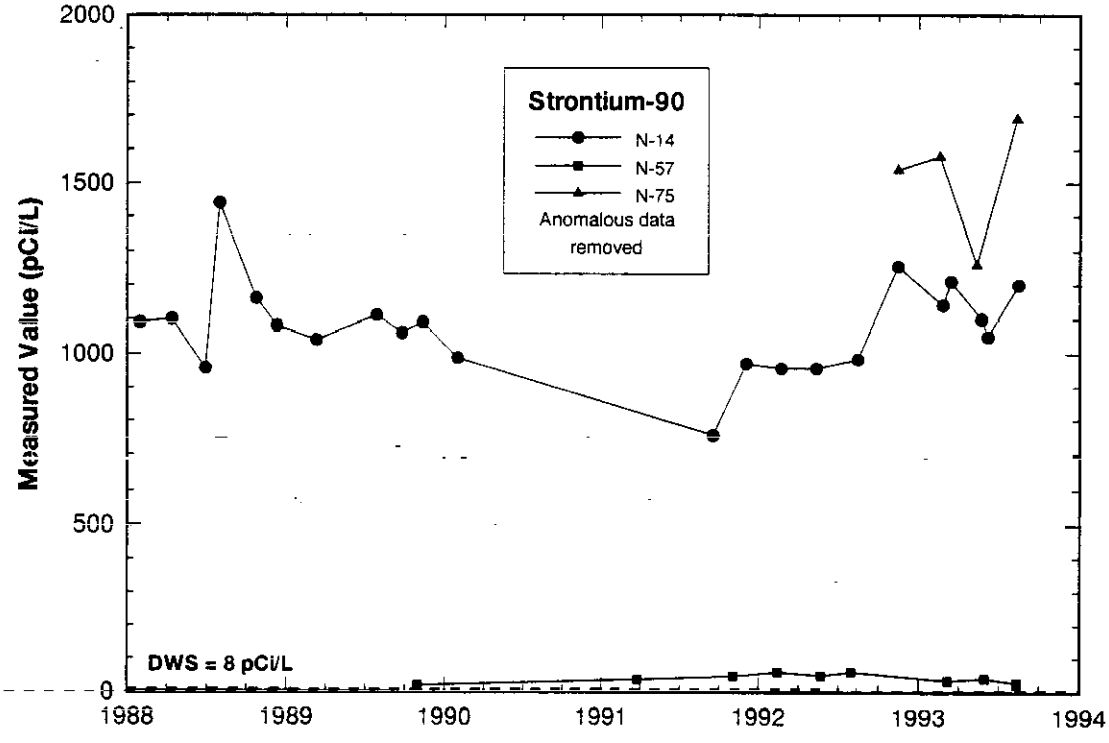
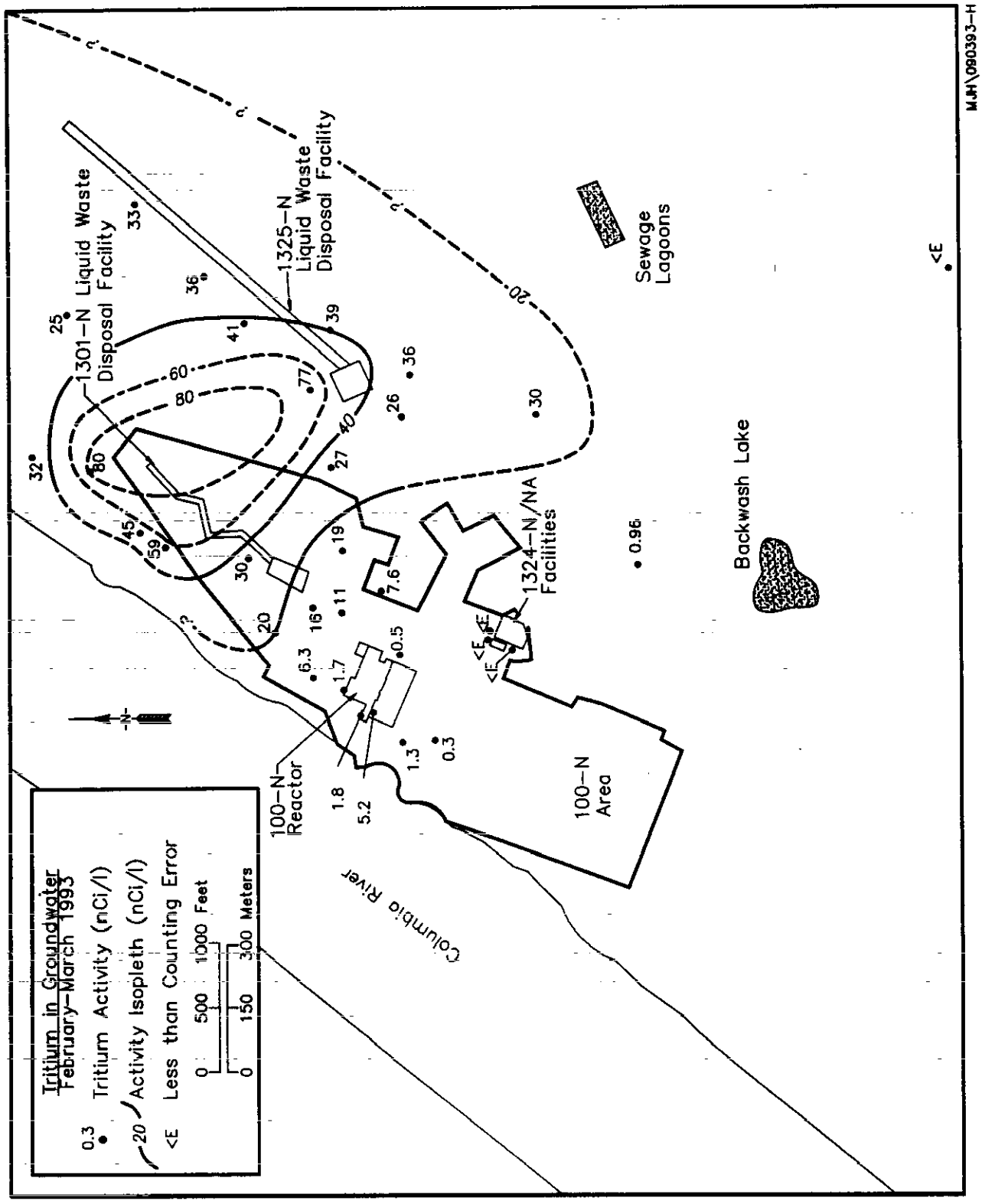


Figure 3.2-7. Tritium in the Uppermost Aquifer Beneath the 100-N Area, February/March 1993 (modified from Hartman and Lindsey 1993).



The northern edge of the tritium plume and its center appear to have moved downgradient since 1990 (Hartman 1991a, 1992a, 1993a; see Figure 3.2-7). However, quantifying this movement is not possible because data distribution does not allow the plume to be defined well enough.

Tritium levels fluctuated in wells near the 1325-N LWDF when the site was in use (Figure 3.2-8). Activities have remained relatively stable during the past 2 years. Tritium levels in well N-14, downgradient of the 1301-N LWDF, have increased since 1990, probably because of the influence of the plume from the 1325-N LWDF (Figure 3.2-9).

Specific conductance is relatively low and stable in most of the downgradient wells in the 1301-N network. It is increasing in wells N-3 and N-2, and is elevated in upgradient well N-57. The source of the elevated specific conductance is the 1324-N/NA site (Hartman 1992b).

Specific conductance at wells downgradient of the 1325-N LWDF has increased since 1989 (Figure 3.2-10). In the past, specific conductance of groundwater beneath the 1325-N LWDF was low because of artificial recharge with low-conductivity water while the site was in use. After discharge to the 1325-N LWDF ceased, specific conductance of groundwater began to increase. High-conductivity groundwater from the 1324-N/NA site also appears to be migrating toward the 1325-N LWDF (Figure 3.2-11). Specific conductance in the upgradient well, N-74, is elevated but declining. Specific conductance in the downgradient wells may be expected to continue to increase as the high-conductivity plume continues to move toward the north.

Groundwater beneath the 1301-N and 1325-N LWDFs has a pH ranging from 7.5 to 8.5. There are no clear upward or downward trends. Replicate averages of TOC have been at or below the contractually required quantitation limit during the past year.

Tritium, gross beta, and ^{90}Sr have been consistently above their drinking water standards in some of the 1301-N and 1325-N wells during the past year. Some metals, such as iron, manganese, and chromium, have been above drinking water standards in unfiltered samples but are not believed to be indicative of groundwater quality (see Section 2.2.4).

3.2.5.2 Statistical Evaluations: 1301-N and 1325-N LWDFs. The 1301-N monitoring network is being sampled quarterly to collect background data from different upgradient wells. After four quarters of data are available, new critical mean values will be established for the indicator parameters.

Statistical evaluations at the 1325-N LWDF during the past year consisted of (1) re-establishing upgradient/downgradient comparison values using data from a new upgradient well (N-74), and (2) comparisons between upgradient and downgradient wells for indication of contamination in the groundwater beneath the site. All values of specific conductance, pH, and TOC in the downgradient wells in the past year were below the upgradient/downgradient comparison values. TOX values were not analyzed due to problems with the data (see Appendix A).

Figure 3.2-8. Tritium Versus Time in Wells N-27, N-29, and N-74.

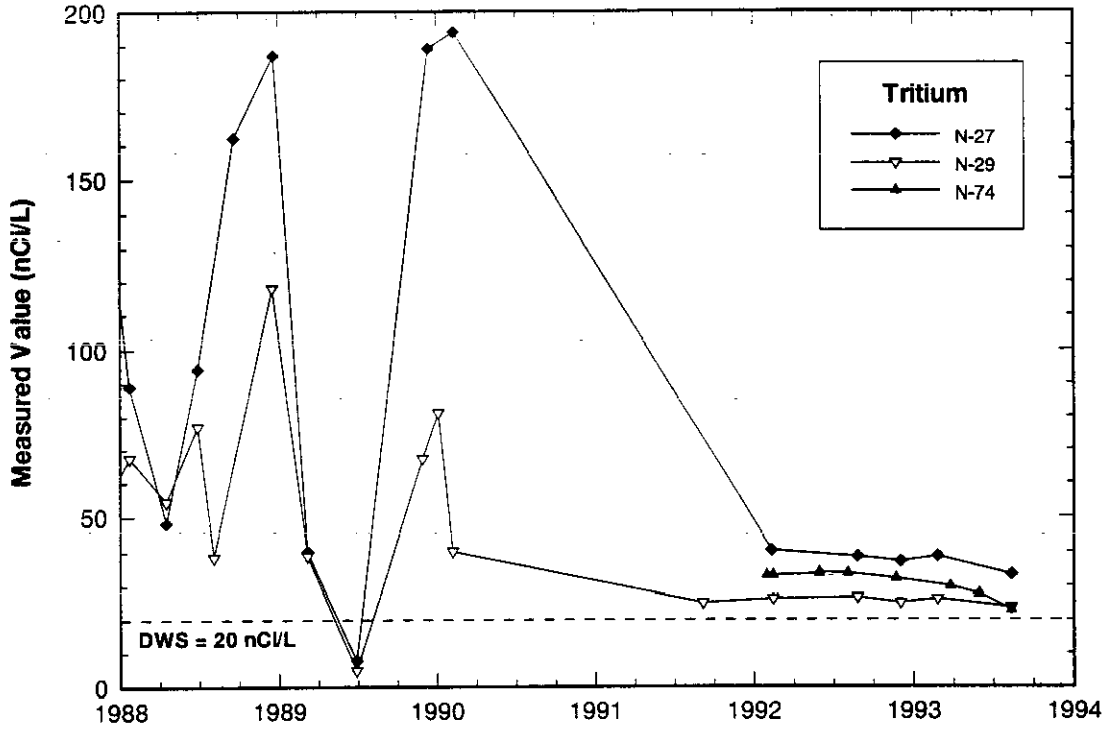


Figure 3.2-9. Tritium Versus Time in Wells N-14, N-57, and N-75.

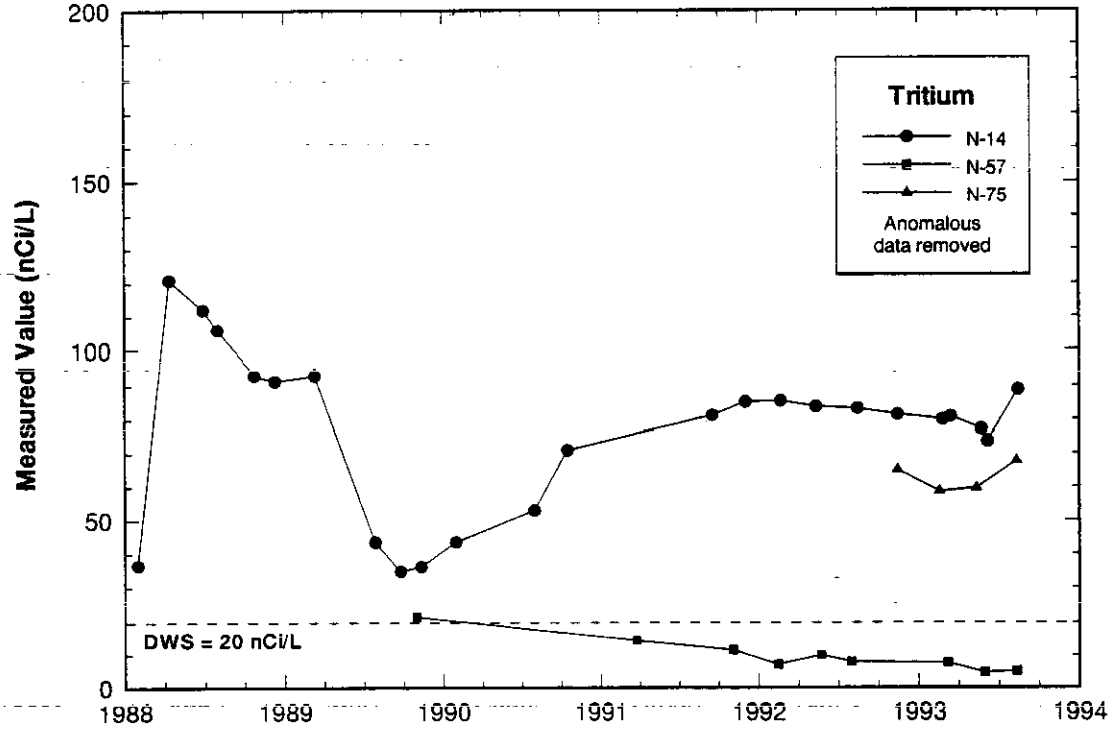


Figure 3.2-10. Conductivity Versus Time in Wells N-27, N-29, and N-74.

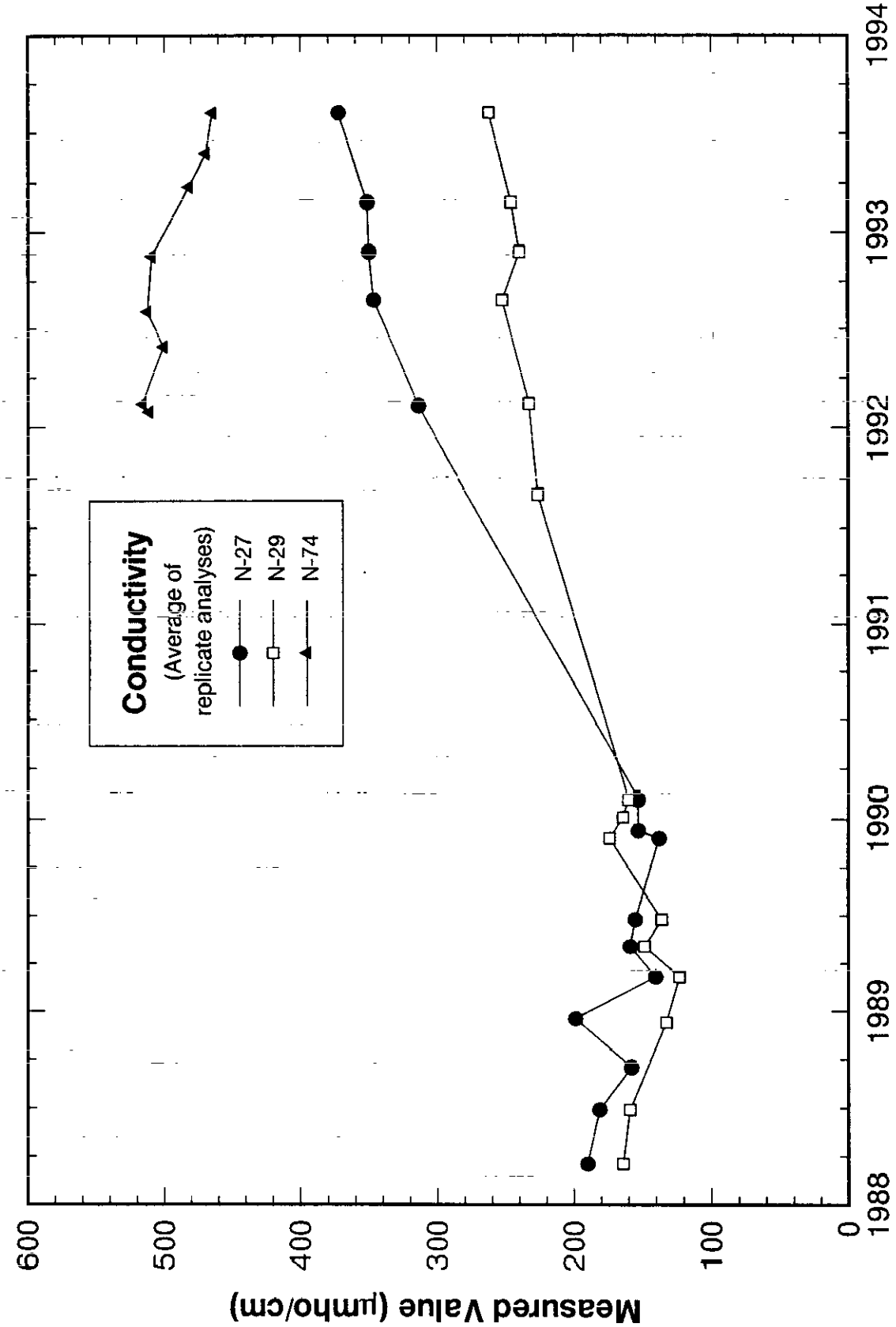
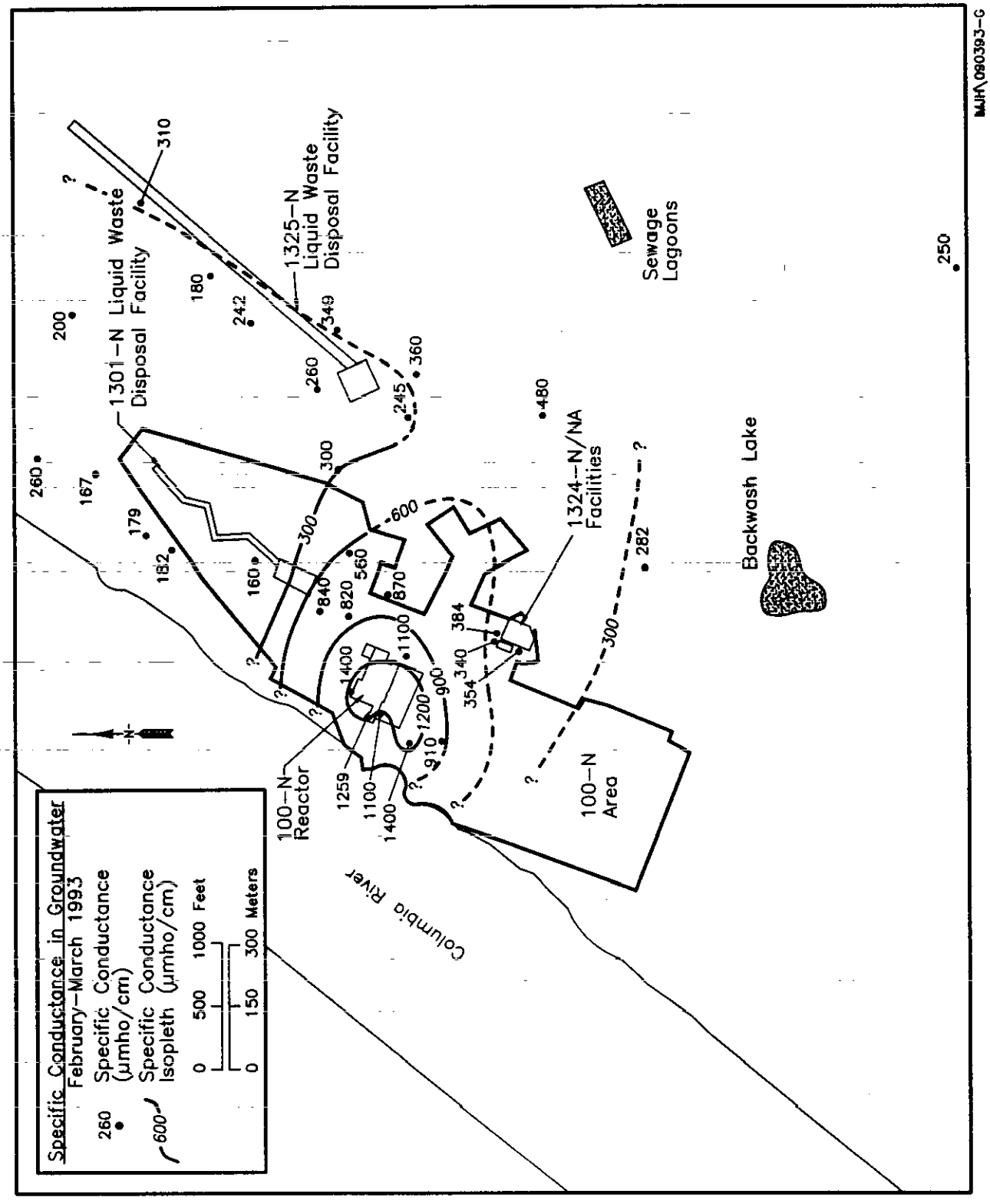


Figure 3.2-11. Conductivity in the Uppermost Aquifer Beneath the 100-N Area, February/March 1993 (Hartman and Lindsey 1993).



Statistical analyses required by 40 CFR 265.93(b) and *Washington Administrative Code* (WAC) 173-303-400 were performed on the samples collected from upgradient well N-74, which was installed in 1991. Supporting data are included in Appendix C; results are presented in Table 3.2-6. This table lists the background average, standard deviation, critical mean (or critical range, in the case of pH), and upgradient/downgradient comparison values for the contamination indicator parameters. The upgradient/downgradient comparison value is the value to which current and future averages of indicator parameters are compared. The comparison value is generally the critical mean or critical range. The limit of quantitation is used as the comparison value for TOC instead of the critical mean because all the upgradient concentrations were below the contractually required quantitation limit (see Appendix C).

3.2.6 Groundwater Chemistry: 1324-N/NA

3.2.6.1 Concentration Histories of Waste Indicators. Groundwater beneath the 1324-N/NA site is characterized by high specific conductance, primarily because of elevated sulfate and sodium. Sulfate concentrations in well N-73 appear to have increased in May and August 1993 (Figure 3.2-12).

Some of the wells in the 1324-N/NA network have had pH at the upper drinking water limit of 8.5 (Figure 3.2-13). This relatively high pH appears unrelated to discharge to the 1324-N/NA site, because upgradient well N-71 has also had a pH at nearly 8.5.

TOX is slightly elevated in some of the 1324-N/NA downgradient wells (Figure 3.2-14). Although the TOX data are in question, the consistency of the elevated values in wells N-72 and N-77 suggests that a halogenated compound is indeed present. The revised assessment program is investigating the elevated TOX (Hartman 1993f).

3.2.6.2 Distribution of Waste Constituents: 1324-N/NA. Results of the groundwater quality assessment program provide no evidence that dangerous constituents from the 1324-N/NA units have entered the groundwater (Hartman 1992b). The 1324-NA Percolation Pond has introduced nondangerous constituents, primarily sulfate and sodium, to the groundwater. The distribution of specific conductance and sulfate are illustrated in Figures 3.2-11 and 3.2-15, respectively.

The highest concentration of sulfate and the highest values of specific conductance were observed in the assessment wells near the river. The plume has migrated from its original position, which was centered on the 1324-N/NA sites (Hartman 1991a).

As discussed above, TOX is elevated in wells N-72 and N-77. The source of the TOX is being investigated, but there is no evidence of a widespread plume.

Table 3.2-6. Critical Means Table for 20 Comparisons--Background Contamination Indicator Parameter Data for the 1325-N Liquid Waste Disposal Facility.[a,b]

Constituent (unit)	n	df	t_c	Average background	Standard deviation	Critical mean	Upgradient/ downgradient comparison value
Specific conductance (μmho/cm)	4	3	12.924	501.75	14.046	704.7	704.7
Field pH	4	3	16.326	7.991	0.129	[5.63, 10.35]	[5.63, 10.35]
Total organic carbon[c] (ppb)	5	3	12.924	500	NC	NC	800
Total organic halogen[d] (ppb)	NC	NC	NC	NC	NC	NC	NC

[a]Data collected from May 1992 to March 1993 for upgradient well 1-N-74. Values calculated based on 20 comparisons.

[b]The following notations are used in this table:

df = degrees of freedom (n-1)
n = number of background replicate averages
t_c = Bonferroni critical t-value for appropriate df and 20 comparisons.

[c]Critical mean cannot be calculated because of lack of an estimate of background standard deviation. The limit of quantitation (based on field blanks data, 1993) is used as the total organic carbon critical mean (see Appendix A).

[d]Critical mean cannot be calculated because of problems associated with data quality.

NC = not calculated.

Figure 3.2-12. Sulfate Versus Time in Wells N-59, N-71, N-72, and N-73.

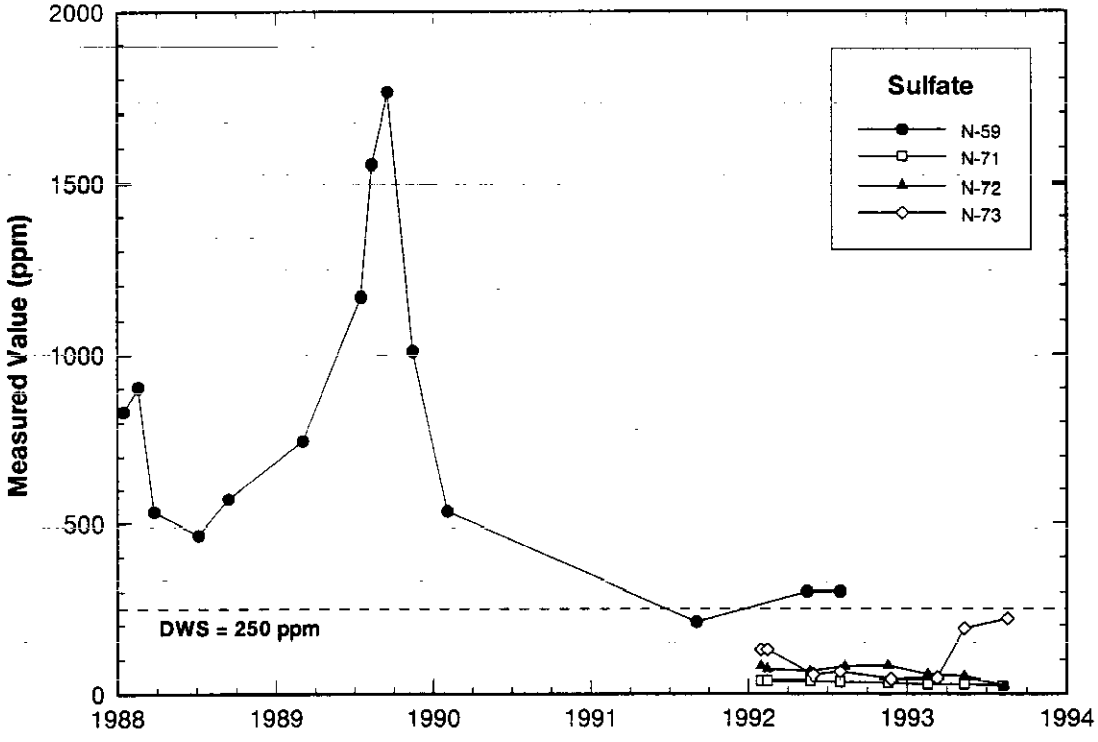
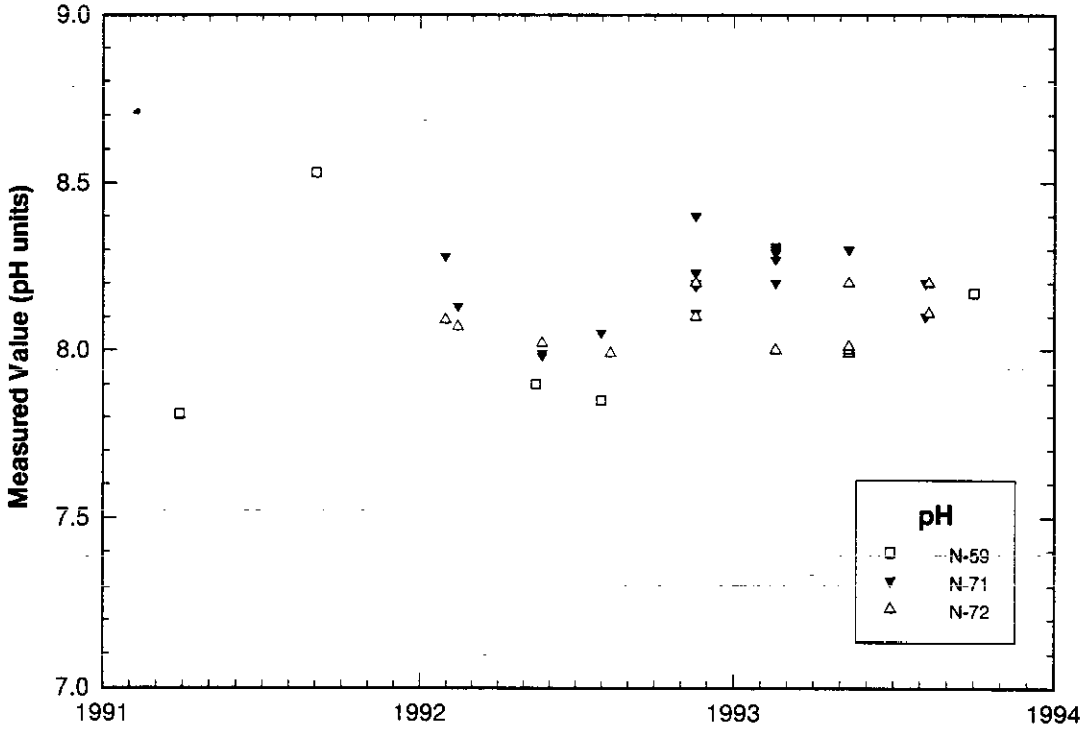


Figure 3.2-13. pH Versus Time in Wells N-59, N-71, and N-72.



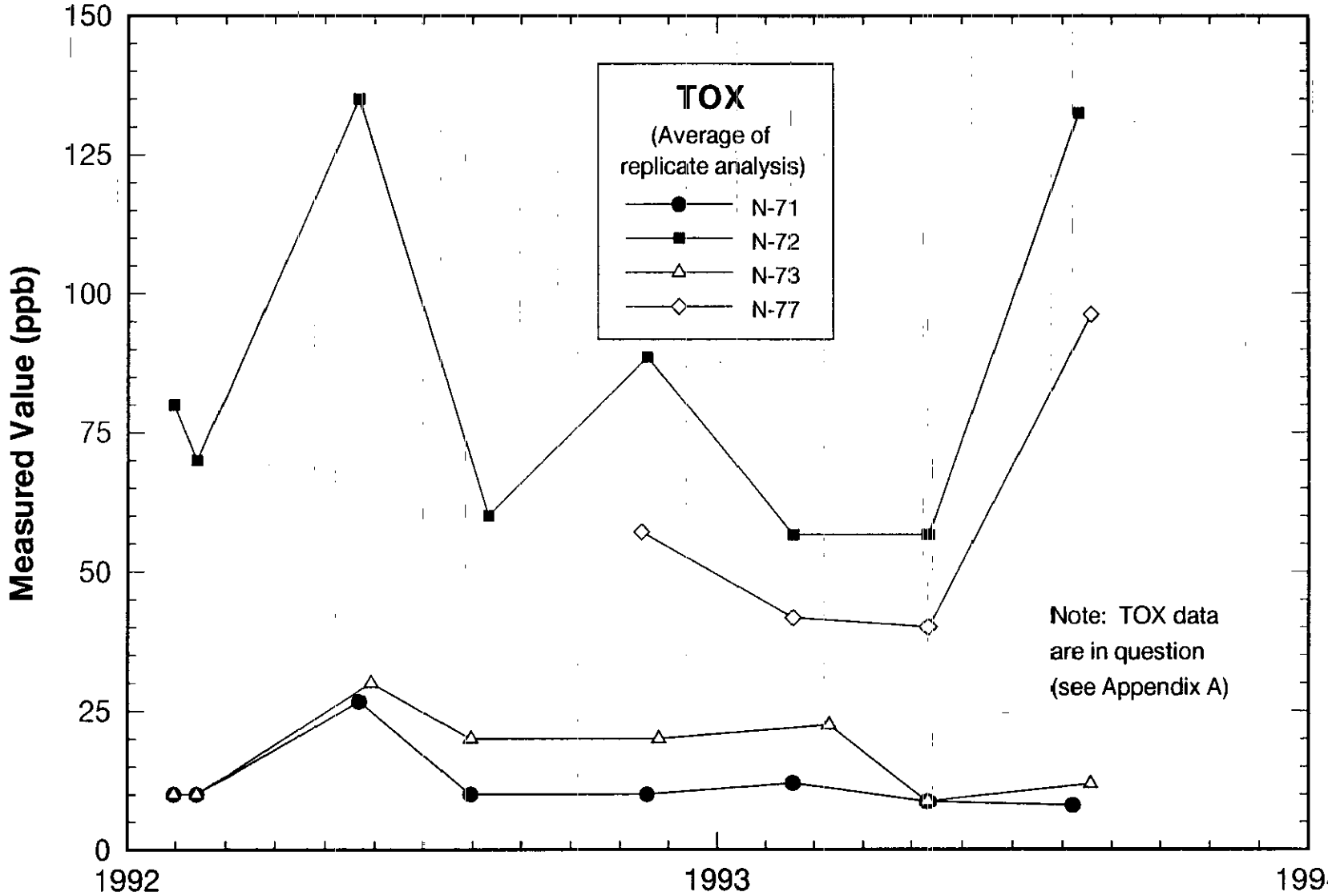
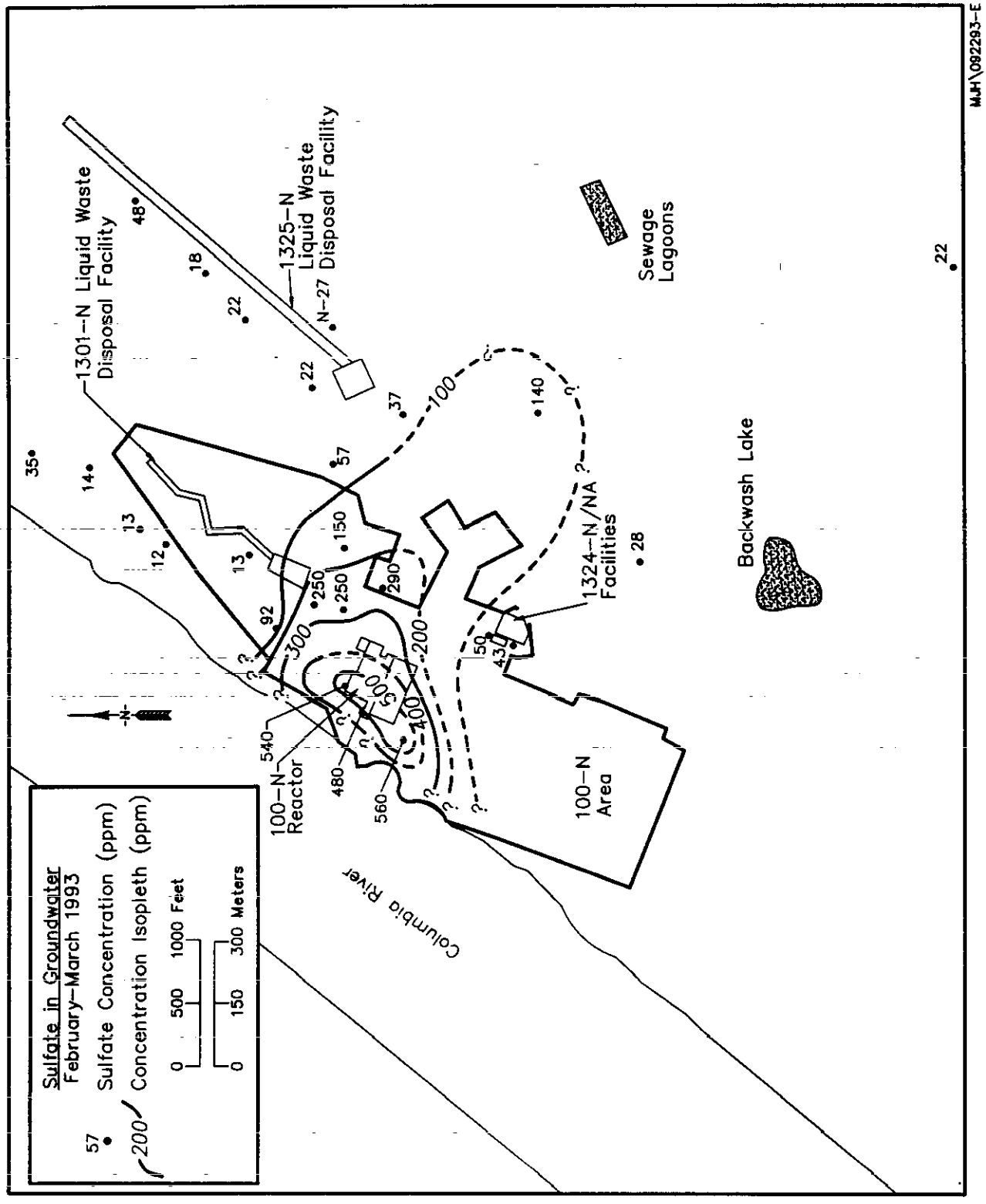


Figure 3.2-14. Total Organic Halogen Versus Time in Wells N-71, N-72, N-73, and N-77.

Figure 3.2-15. Sulfate in the Uppermost Aquifer Beneath the 100-N Area, February/March 1993 (Hartman and Lindsey 1993).



3.2.7 Groundwater Flow

This section describes the direction and rate of groundwater flow beneath the 1301-N, 1325-N, and 1324-N/NA sites.

3.2.7.1 Groundwater Flow Direction. Figures 3.2-16 and 3.2-17 show the water table beneath the 100-N Area in May and June 1993, respectively. The river level was high in May, and there was a potential for water to flow out of the river into the aquifer. By mid-June the river level had declined, the water table had reverted to its average position, and groundwater flowed from the aquifer to the river.

Groundwater is more strongly influenced by river stage near the 1301-N LWDF than near the other RCRA sites, because the 1301-N site is closest to the river. In May, groundwater adjacent to the river may have flowed roughly parallel to it. In June, groundwater is inferred to flow toward the river (i.e., toward the northwest) beneath the 1301-N LWDF. The horizontal gradient between wells N-34 and N-75 in June was 2×10^{-3}.

Groundwater flows primarily toward the north beneath the 1325-N LWDF, as inferred from the water table. River stage did not affect the direction of groundwater flow at the 1325-N site during the past year. The horizontal gradient between wells N-28 and N-49 in June was 1×10^{-3}.

The general direction of groundwater flow beneath the 1324-N/NA site is toward the northwest. However, there seem to be local anomalies to this pattern. Water levels in well N-72 are consistently about 0.3 m (1 ft) higher than in well N-73 (Figure 3.2-18). The horizontal gradient between wells N-72 and N-26 in June was 4×10^{-3}.

Vertical gradients are not well known in the 100-N Area. Wells adjacent to the Columbia River show an upward gradient in the uppermost aquifer (Hartman and Lindsey 1993). Further inland there is no significant difference in head between wells completed at the water table and wells completed at the base of the aquifer, approximately 6 m (20 ft) deeper. Limited data preyent a clear comparison of vertical heads in the unconfined and shallowest confined Ringold aquifers.

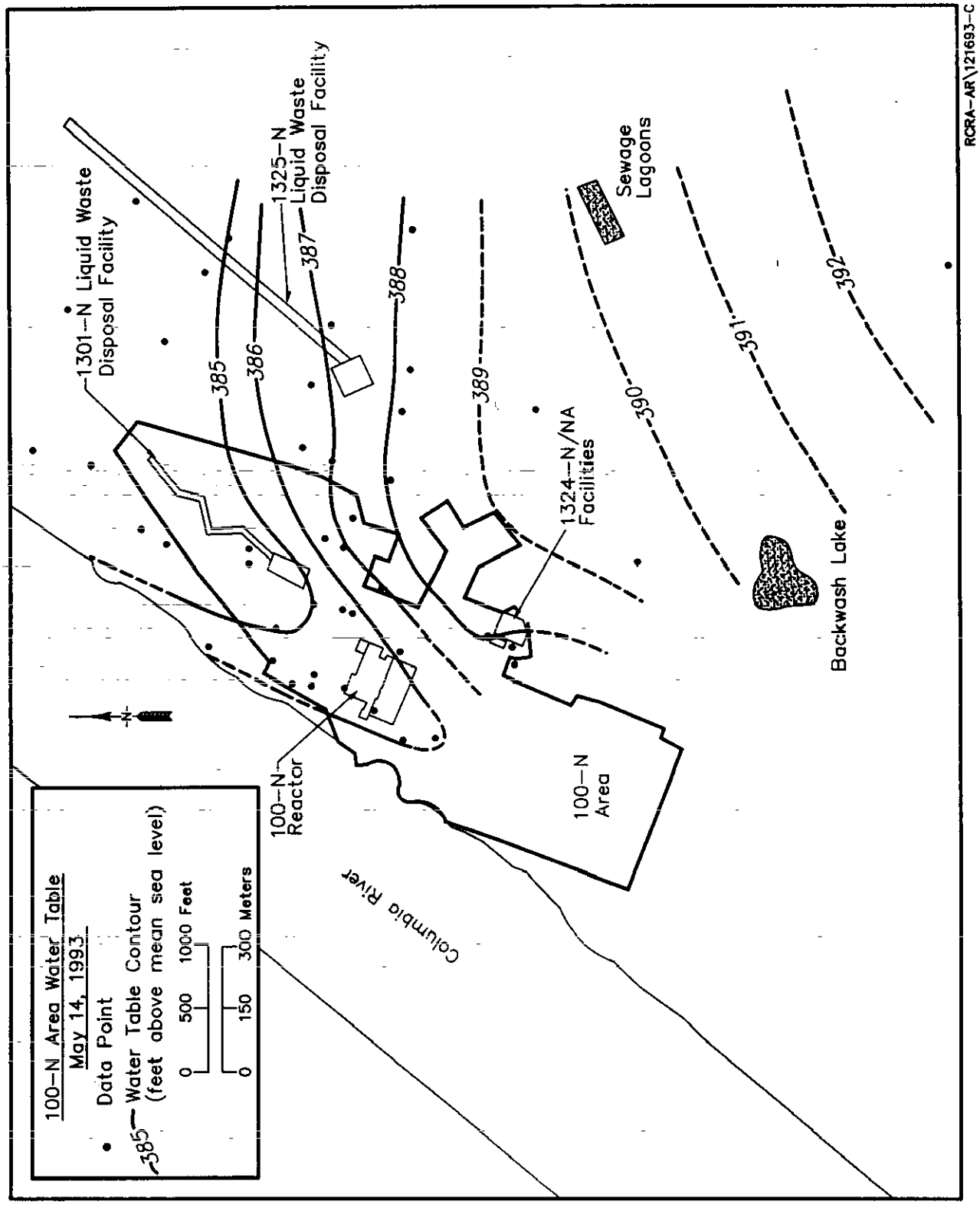
3.2.7.2 Rate of Flow. The rate of groundwater flow can be estimated by using a form of the Darcy equation with a range of input parameters.

$$v = \frac{Ki}{n_e} \qquad (1)$$

where:

- v = Average linear velocity of groundwater
- K = Horizontal hydraulic conductivity
- i = Hydraulic gradient
- n_e = Effective porosity of the aquifer.

Figure 3.2-16. Water Table Map in the 100-N Area, May 1993.



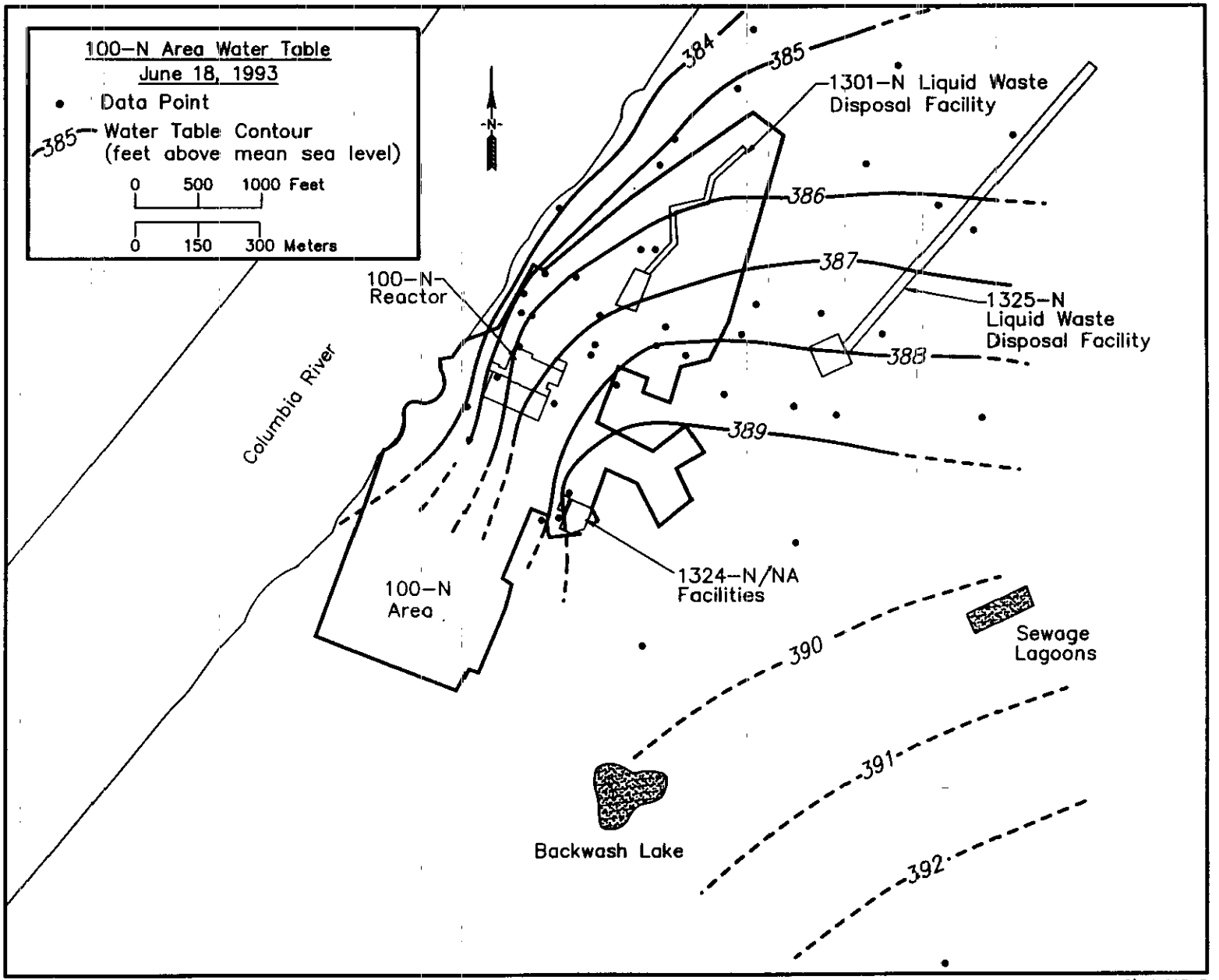
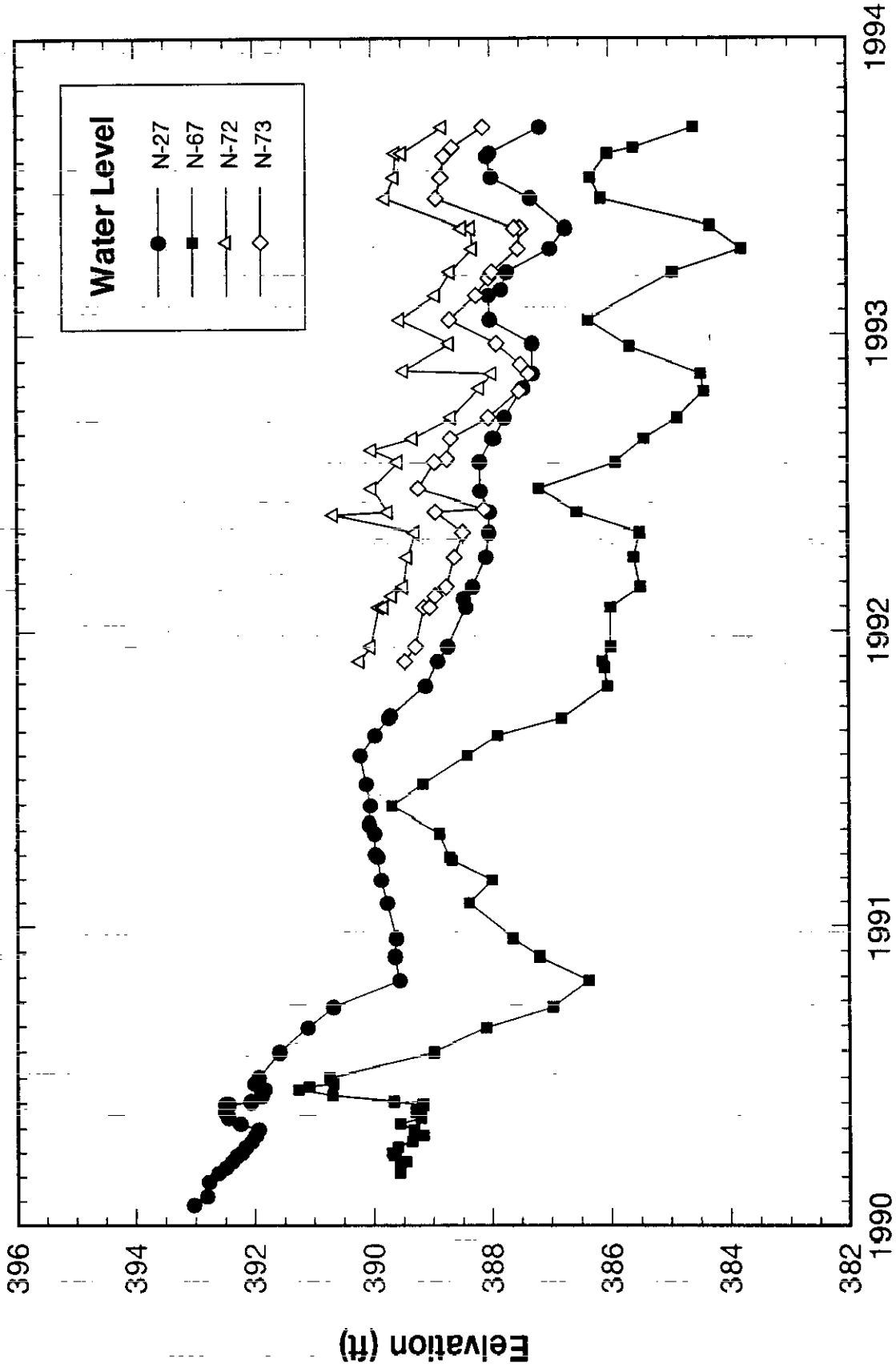


Figure 3.2-17. Water Table Map in the 100-N Area, June 1993.

Figure 3.2-18. Water Levels Versus Time in the 100-N Area.



The following input parameters were used:

K = 6.1 to 36.6 m/d (20 to 120 ft/d) (Gilmore et al. 1992)
i = 2×10^{-3} (1301-N)
1×10^{-3} (1325-N)
4×10^{-3} (1324-N/NA)
n_e = 0.1 to 0.3.

Resulting estimates of groundwater velocity are as follows:

1301-N LWDF: 0.04 to 0.73 m/d (0.1 to 2 ft/d)
1325-N LWDF: 0.02 to 0.37 m/d (0.1 to 1 ft/d)
1324-N/NA: 0.08 to 1.5 m/d (0.3 to 5 ft/d)

The movement of contaminants in groundwater can sometimes be used to estimate their velocity. The boundaries and the center of the tritium plume beneath the 1301-N and 1325-N LWDFs are not well enough defined to estimate the distance of its movement. Tritium activities fluctuated during the use of the 1325-N LWDF, so there are no clear peak activities to trace between wells.

There was no apparent movement of the ^{90}Sr plumes between 1990 and 1993 (Hartman 1991a, 1992a, 1993a; see Figure 3.2-4). This contaminant has a low mobility in groundwater.

The movement of the sulfate plume downgradient from the 1324-N/NA site can provide an estimate of its velocity. The center of the plume was beneath the 1324-N/NA site in 1990 (Hartman 1991a); it is now near the river (see Figure 3.2-15). This represents a horizontal distance of at least 460 m (1,500 ft). The center of the plume could have already migrated past this area and have disappeared into the Columbia River; thus this estimate should yield a minimum velocity. Dividing distance by time gives a velocity for sulfate of approximately 0.46 m/d (1.5 ft/d), which is within the range calculated from Equation 1.

3.2.7.3 Evaluation of Monitoring Well Networks. Low water levels and logistical problems restricted sampling of some wells during the past year. In the 1301-N network, wells N-57 and N-67 were not sampled as frequently as planned because of low water levels. Groundwater levels appear to have stabilized. It may be possible to pump samples from the wells, at least during times of the year when the water table is relatively high. Access to wells N-2 and N-3 was complicated by their location in a radiation zone, but the access problem has been solved. At this time the 1301-N network is judged to be adequate. If there are continued problems while sampling these wells, the network will be reevaluated.

Well N-43 was added to the 1325-N network in 1993 to monitor the northern segment of the trench. Access to well N-43 was limited, but a new road and gate were installed and the well will be sampled regularly in the coming year. Well N-81 was installed to replace a dry well. At this time the 1325-N network is considered adequate.

Well N-59, in the 1324-N/NA network, contains very little water and was not sampled during the period covered in this report. The well was sampled with a bailer in October 1993. If samples cannot be pumped from the well, bailed samples will be collected. At this time the 1324-N/NA network is considered adequate.

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3.3 100-D PONDS

M. J. Hartman
Westinghouse Hanford Company

This chapter describes groundwater monitoring at the 100-D Ponds, a *Resource Conservation and Recovery Act of 1976* (RCRA) disposal unit located in the 100-D Area of the U.S. Department of Energy's (DOE) Hanford Site (see Figure 1-1, Chapter 1.0). The 100-D Ponds monitoring program began in 1991 and the four wells in the network were sampled for the first time in 1992. The groundwater monitoring program is described in Hartman (1991). Background values have been established and the site is monitored in an indicator evaluation program.

3.3.1 Facility Overview

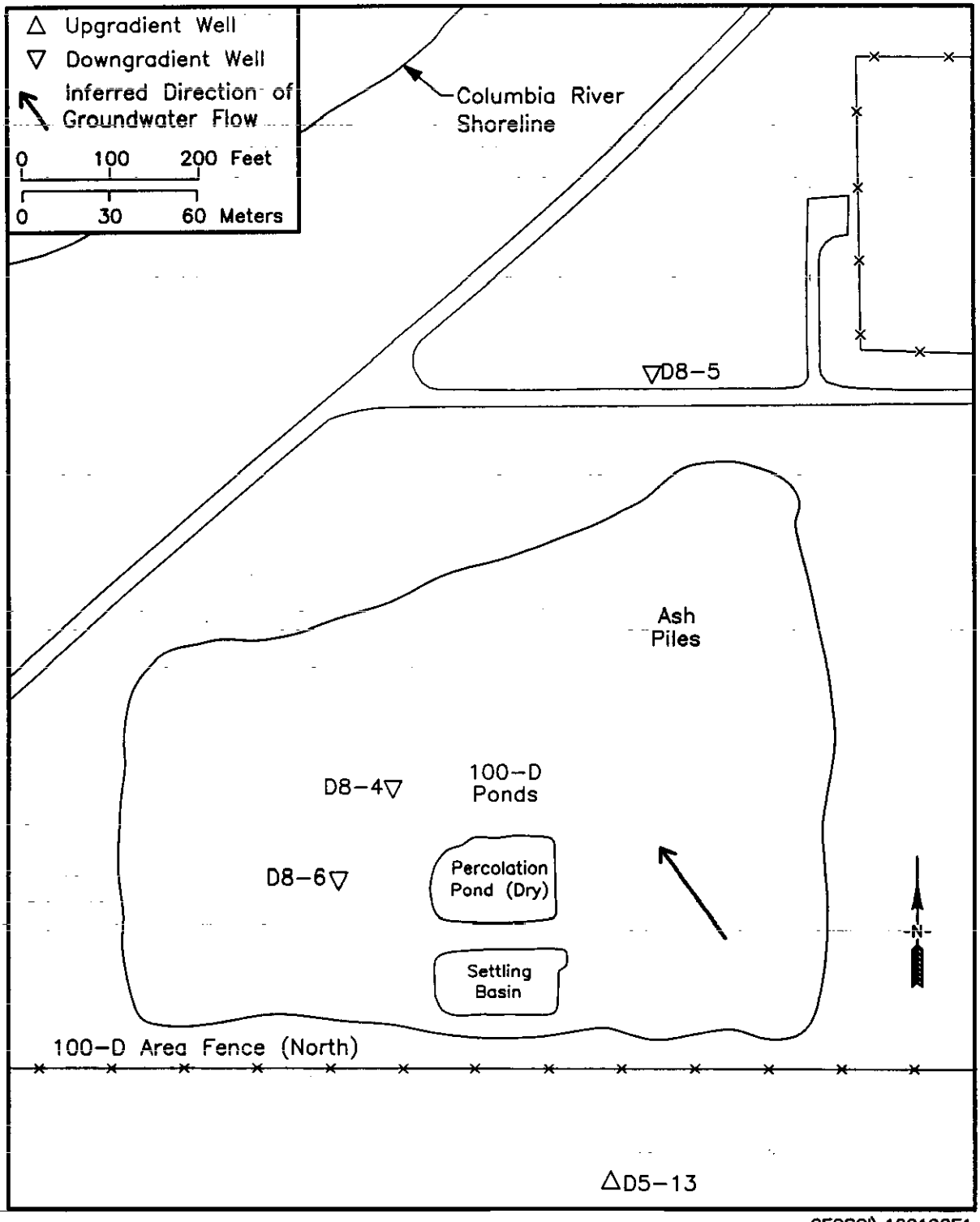
The 100-D Ponds facility was constructed in 1977 for disposal of nonradioactive effluents derived from 100-D Area operating facilities. The 100-D Ponds are located in the former 188-D Ash Disposal Basin. The 100-D Ponds include a settling pond and a percolation pond, separated by a dike (Figure 3.3-1).

Effluent to the 100-D Ponds originated from two sources: (1) the 183-D Filter Plant and (2) the 189-D Building engineering testing laboratories. Some past discharges contained hydrochloric acid, sulfuric acid, and sodium hydroxide. Before 1986, the effluent may have had pH greater than 12.5 or less than 2.0 and, thus may have been dangerous waste. There was also a potential for up to 2.3 kg (5 lb) of mercury to have been discharged to the 100-D Ponds. The 183-D Filter Plant still discharges low volumes of nondangerous effluent to the ponds (WHC 1990). The current effluent may include chlorine and flocculating agents such as aluminum sulfate.

The 100-D Ponds are regulated under the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) program. Groundwater beneath the 100-D Area is considered part of the 100-HR-3 operable unit. The 100-D Ponds themselves are located in the 100-DR-1 source operable unit. Hydrogeologic data from CERCLA wells were interpreted in this section along with data from the 100-D Ponds RCRA wells to better understand the hydrogeology of the 100-D Area.

The uppermost aquifer beneath the 100-D Ponds is a sand and gravel unit in the Ringold Formation (Figure 3.3-2), approximately 3 to 9 m (10 to 30 ft) thick. This unit corresponds to Ringold unit E (see Sections 2.1 and 3.1). The base of the aquifer is a fine-grained overbank interval, which is approximately 15 m (50 ft) thick elsewhere in the 100-D Area (DOE-RL 1993).

Figure 3.3-1. Groundwater Monitoring Wells Located Near the 100-D Ponds.



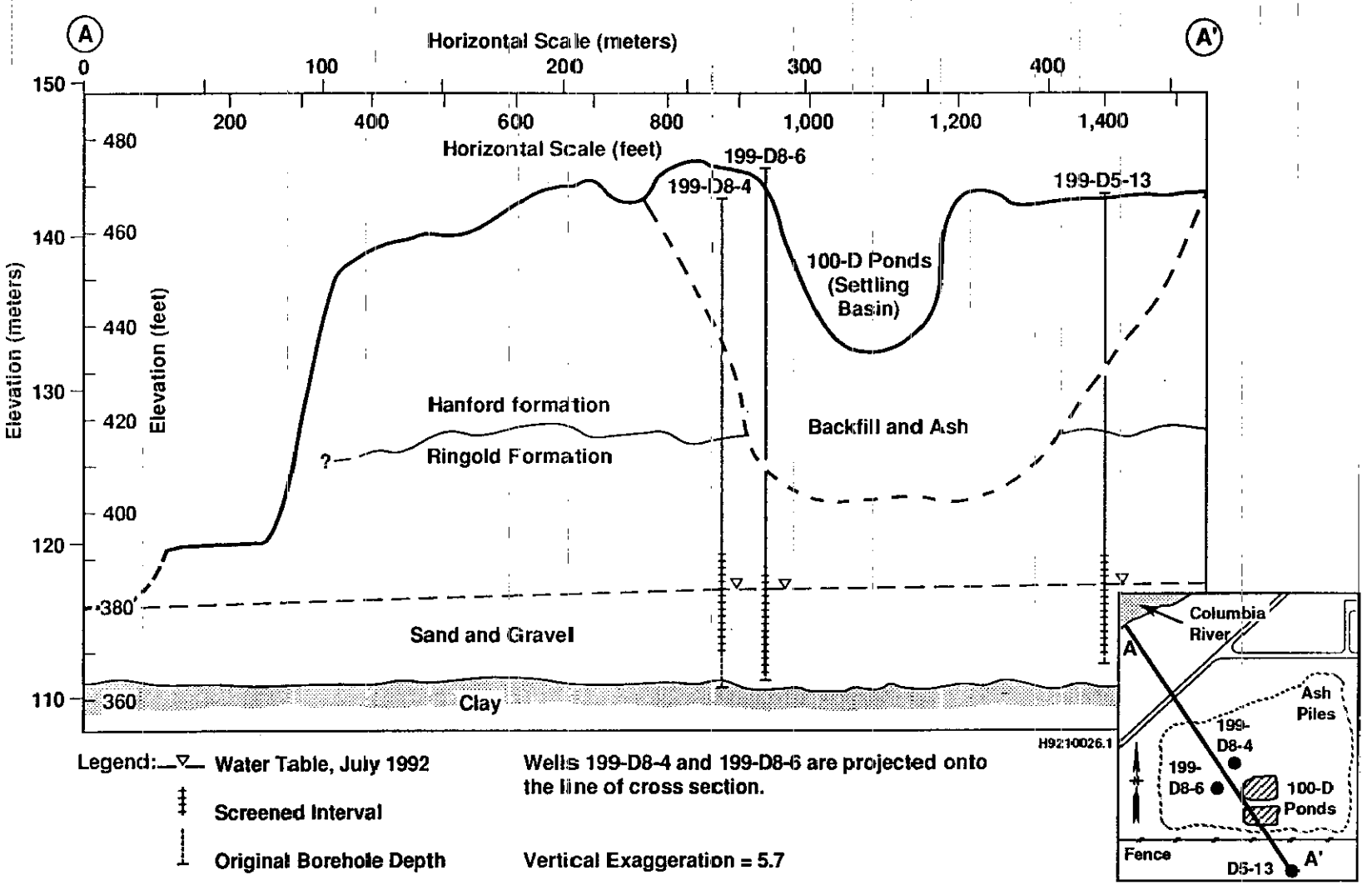


Figure 3.3-2. Geologic Cross Section Through the 100-D Ponds (DOE-RL 1993).

3.3.2 Summary of 1993 RCRA Activities

The wells in the 100-D Ponds network were sampled in December 1992, March 1993, and June 1993. The first four quarters of monitoring were completed during 1993. Indicator parameter data from the upgradient well were evaluated statistically to determine background conditions, and monitoring frequency changed from quarterly to semiannually. Water levels were measured monthly.

A closure plan for the 100-D Ponds was submitted to the regulators in February 1993 (DOE-RL 1993).

3.3.3 Other Activities in 1993

Hydrogeologic studies for the 100-HR-3 operable unit continued in 1993. Lindsey and Jaeger (1993) describe the geology of the operable unit, which includes the 100-D and 100-H Areas and the area between them.

A groundwater impact assessment was prepared for the 100-D Ponds (Alexander 1993). The study postulated that: (1) concentrations of local contaminants are diluted by 100-D Ponds effluent; (2) effluent percolates through backfill/ash and reacts with the lime and periclase in the ash to form hydroxides; (3) the hydroxides dissociate in the vadose zone and raise the pH to a slightly alkaline range; (4) less mobile metal cations are retained in the soil column; and (5) more mobile species are flushed through the system. The ponds continue to receive nondangerous effluent at a rate of approximately 984,000 L/mo (260,000 gal/mo).

Wells in the 100-D Area were sampled twice for the 100-HR-3 groundwater operable unit.

3.3.4 Sampling and Analysis Program

The monitoring program for the 100-D Ponds is described by Hartman (1991). Four wells are sampled under RCRA for the 100-D Ponds. Additional wells are used to monitor water levels. Table 3.3-1 lists the wells monitored for water levels and/or chemistry for the 100-D Ponds RCRA program. The locations of the wells are shown in Figure 3.3-3.

The RCRA sampling network consists of one upgradient well (D5-13[1]) and three downgradient wells. Two of the downgradient wells (D8-4 and D8-6) are located adjacent to the 100-D Ponds. The remaining well (D8-5) is located farther from the facility, outside of the ash mounds and nearer the river. The location of this well was determined in discussions with the Washington State Department of Ecology, to provide more information on river/aquifer relationships. Samples are collected and analyzed from well D8-5 but statistical comparisons to the upgradient well are not performed.

---

[1]Well numbers are abbreviated in Section 3.3 by deleting prefix numbers. Wells in the 100-D Area (e.g., D8-4, D5-13) have the prefix 199-. Wells in the 600 Area (e.g., 87-55) have the prefix 699-.

Table 3.3-1. Wells Monitored for Chemistry or Water Levels for the 100-D Ponds. (sheet 1 of 2)

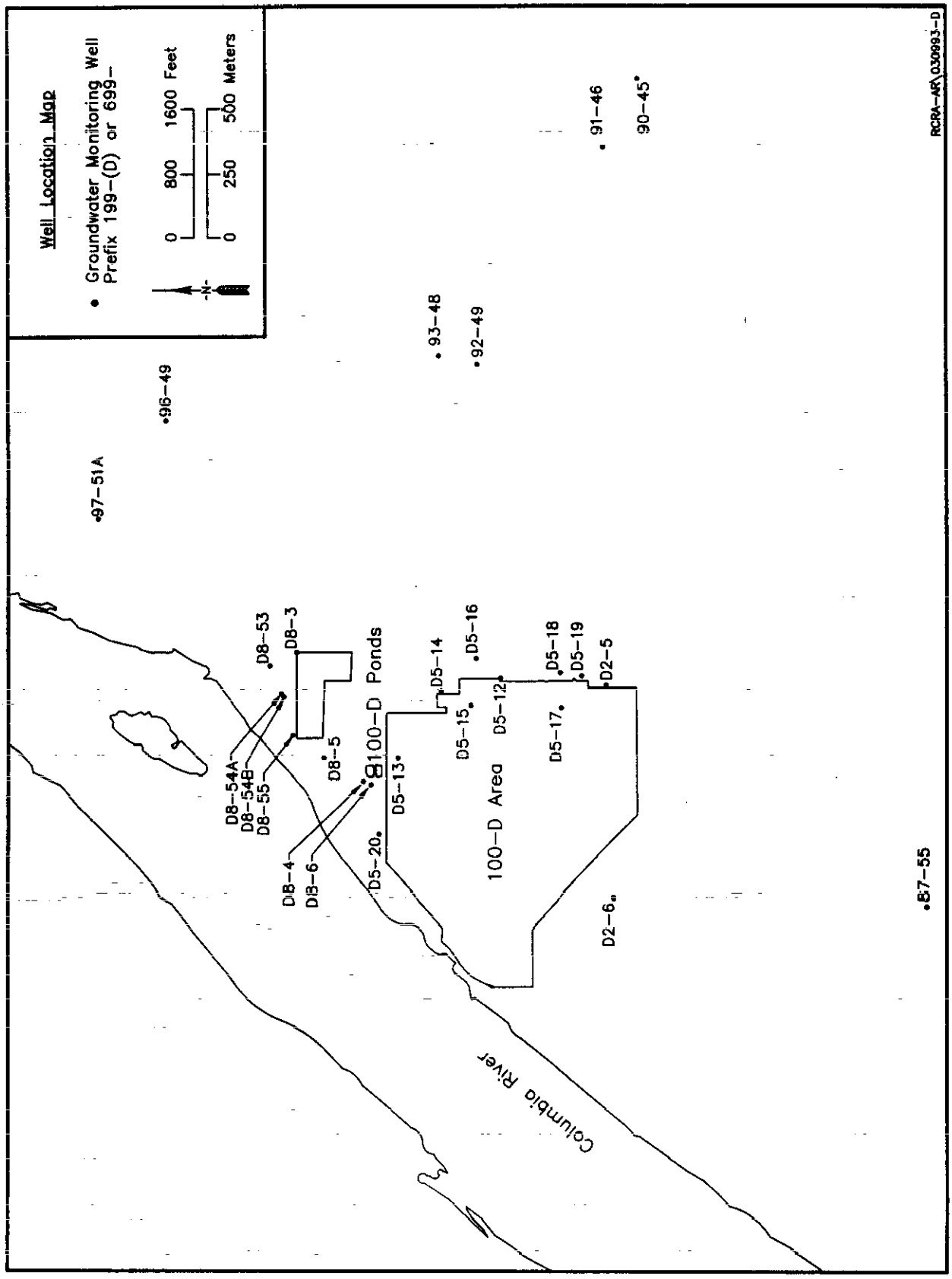
Well	Aquifer	RCRA sampling frequency	Water levels	Well standards	Other networks
199-D2-5[60]	Top of unconfined	--	M	PRE	100-HR-3
199-D2-6[92]	Top of unconfined	--	M	RCRA	100-HR-3
199-D5-12[60]	Top of unconfined	--	M	PRE	100-HR-3
199-D5-13[91]	Top of unconfined	SA	M	RCRA	100-HR-3
199-D5-14[92]	Top of unconfined	--	M	RCRA	100-HR-3
199-D5-15[92]	Top of unconfined	--	M	RCRA	100-HR-3
199-D5-16[92]	Top of unconfined	--	M	RCRA	100-HR-3
199-D5-17[92]	Top of unconfined	--	M	RCRA	100-HR-3
199-D5-18[92]	Top of unconfined	--	M	RCRA	100-HR-3
199-D5-19[92]	Top of unconfined	--	M	RCRA	100-HR-3
199-D5-20[92]	Top of unconfined	--	M	RCRA	100-HR-3
199-D8-3[52]	Top of unconfined	--	M	PRE	100-HR-3
199-D8-4[91]	Top of unconfined	SA	M	RCRA	100-HR-3
199-D8-5[91a]	Top of unconfined	SA	M	RCRA	100-HR-3
199-D8-6[91]	Top of unconfined	SA	M	RCRA	100-HR-3
199-D8-53[92]	Top of unconfined	--	M	RCRA	100-HR-3
199-D8-54A[92]	Top of unconfined	--	M	RCRA	100-HR-3
199-D8-54B[92]	Top of unconfined	--	M	RCRA	100-HR-3
199-D8-55[92]	Shallow confined	--	M	RCRA	100-HR-3
699-87-55[b]	Top of unconfined	--	M	PRE	--
699-90-45[b]	Top of unconfined	--	M	PRE	--
699-91-46[92]	Top of unconfined	--	M	RCRA	100-HR-3
699-92-49[b]	Top of unconfined	--	M	PRE	--
699-93-48[92]	Top of unconfined	--	M	RCRA	100-HR-3

Table 3.3-1. Wells Monitored for Chemistry or Water Levels for the 100-D Ponds. (sheet 2 of 2)

Well	Aquifer	RCRA sampling frequency	Water levels	Well standards	Other networks
699-96-49[62]	Top of unconfined	--	M	PRE	100-HR-3
699-97-51A[b]	Top of unconfined	--	M	PRE	100-HR-3

Notes: Shading denotes upgradient well in sampling network.
Superscript following well number denotes the year of installation.
[a]Well 199-D8-5 will not be used for detection purposes, per agreement with the Washington State Department of Ecology.
[b]The year of well completion is unknown.
M = frequency on a monthly basis.
PRE = well was not constructed to RCRA standards.
RCRA = well is in compliance with RCRA standards.
SA = frequency on a semiannual basis; was quarterly until June 1993.

Figure 3.3-3. Groundwater Monitoring Wells In and Near the 100-D Area.



Samples are analyzed for the constituents listed in Table 3.3-2. Sampling frequency switched from quarterly to semiannually after the June 1993 sampling. Water levels are measured monthly in most of the wells in the 100-D Area and vicinity (see Table 3.3-1 and Figure 3.3-3). Water levels and results of chemical analyses are presented in quarterly reports (Hartman 1993a, 1993b, 1993c, 1994).

3.3.5 Groundwater Chemistry

3.3.5.1 Constituents of Concern. The indicator parameters for the 100-D Ponds are: pH, specific conductance, total organic carbon (TOC), and total organic halogen (TOX) (40 *Code of Federal Regulations* [CFR] 265.92[b][3]). TOC was detected in samples from all four wells in June 1993. However, the values were associated with laboratory blank contamination. TOX was not regularly detected and data are in question (see Appendix A). The pH tends to be higher in the wells immediately adjacent to the ponds (D8-4 and D8-6) than in the upgradient well (D5-13) or the well further downgradient (D8-5) (Figure 3.3-4). This may be due to the influence of the ash, as discussed in Section 3.3.3 (Alexander 1993). Specific conductance is lower in the wells nearest the ponds (Figure 3.3-5). This is likely due to dilution by artificial recharge from the ponds.

Mercury is a dangerous waste constituent that was potentially discharged to the 100-D Ponds (DOE-RL 1993). No mercury has been detected in 100-D Ponds downgradient wells.

Nitrate, chromium, and tritium are elevated in the 100-D Area from sources other than the 100-D Ponds (Figures 3.3-6, 3.3-7, and 3.3-8). Each of these constituents is lowest in the area surrounding the 100-D Ponds. As with specific conductance, this is likely because pond effluent dilutes local groundwater.

Tritium is elevated in well 87-55, as it has been for many years. The well is located south of the 100-D Area (see Figure 3.3-3). Tritium-contaminated groundwater may have entered this location from the 100-N and/or 100-D Areas when large groundwater mounds existed beneath effluent disposal sites in those areas.

Some metals (e.g., chromium and iron) have been above drinking water standards in unfiltered samples during the past year, but are not believed to represent groundwater quality (see Section 2.2.4).

3.3.5.2 Statistical Evaluation. Indicator parameter data (excluding TOX) from upgradient well D5-13 were statistically evaluated as required by 40 CFR 265.93(b) and *Washington Administrative Code* (WAC) 173-303-400. Table 3.3-3 lists background averages, standard deviations, critical mean values, and upgradient/downgradient comparison values for the indicator parameters. Supporting tables are included in Appendix C. The upgradient/downgradient comparison value is the value to which current and future averages of indicator parameters are compared. The comparison value is

Table 3.3-2. Constituent List for 100-D Ponds.

Contamination indicator parameters		
pH (field and lab) Specific conductance (field and lab)	Total organic carbon Total organic halogen	
Groundwater quality parameters		
Chloride Iron	Manganese Phenols	Sodium Sulfate
Drinking water parameters		
Arsenic Barium Cadmium Chromium Coliform	Fluoride Gross alpha Gross beta Lead Mercury	Nitrate Radium Selenium Silver Turbidity
Site-specific parameters		
Temperature Tritium		

Figure 3.3-4. pH Versus Time in 100-D Pond Wells.

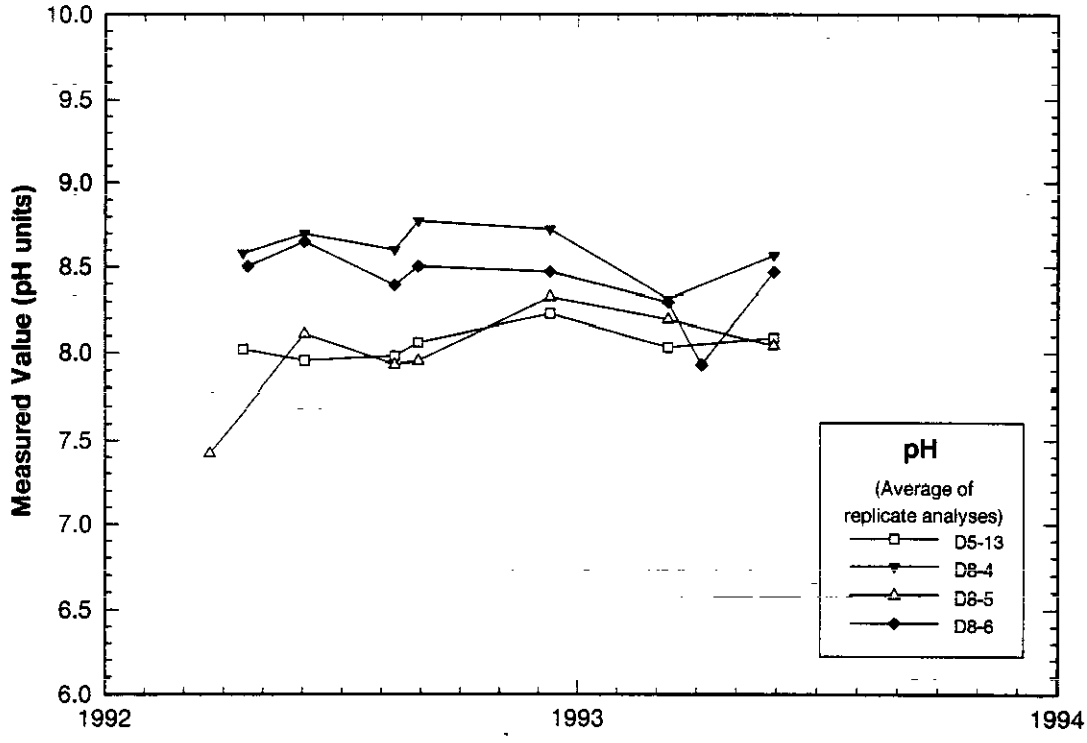


Figure 3.3-5. Conductivity Versus Time in 100-D Pond Wells.

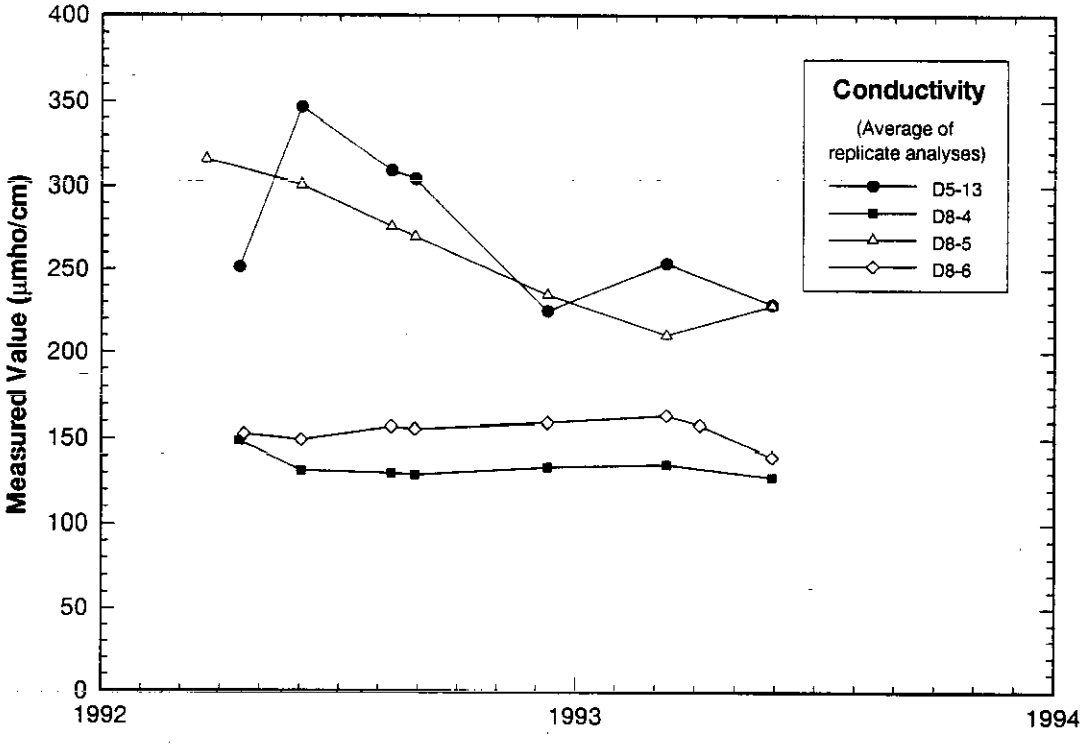


Figure 3.3-6. Nitrate in the Uppermost Aquifer, 100-D Area, February/March 1993.

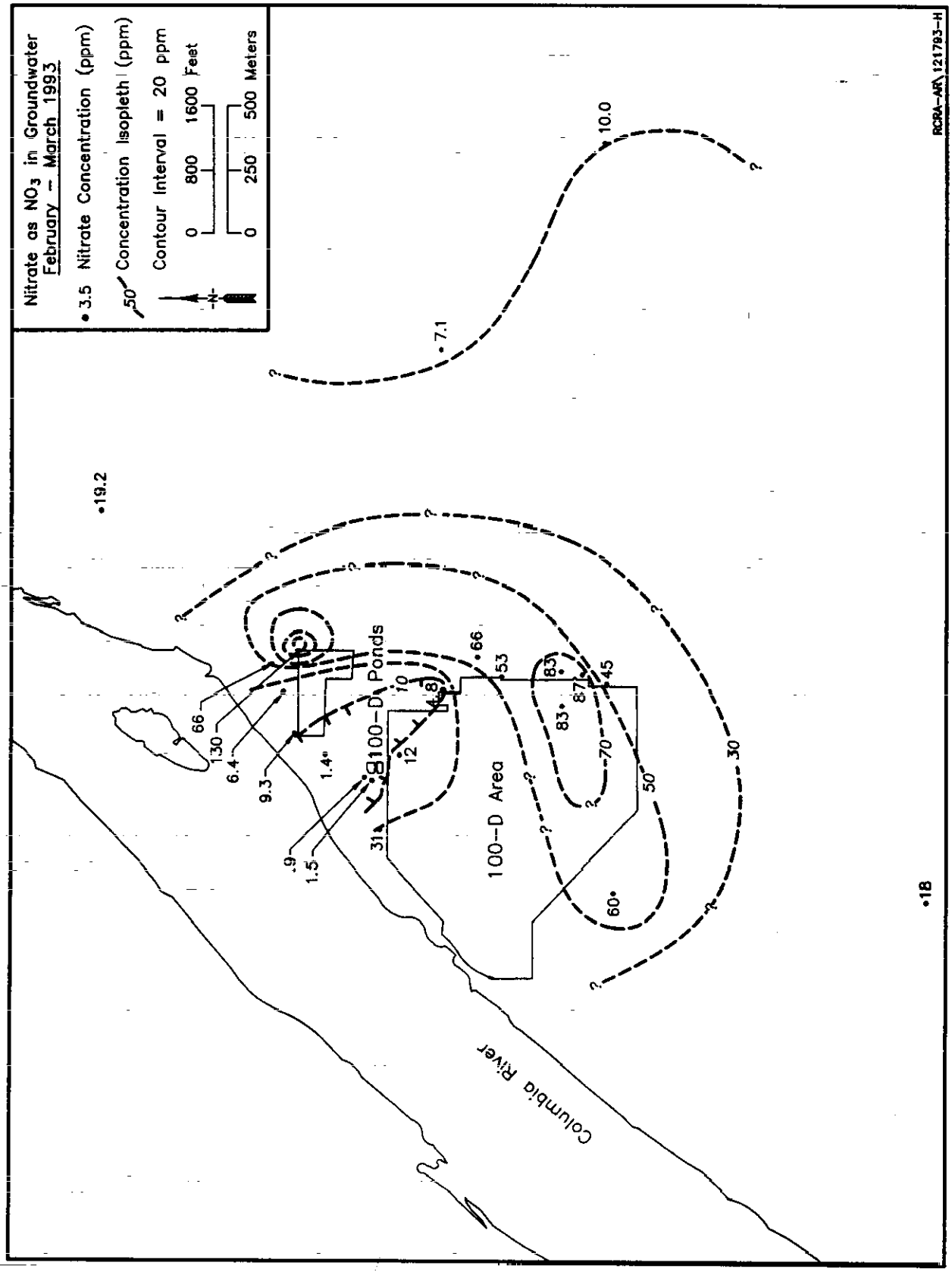


Figure 3.3-7. Chromium in the Uppermost Aquifer, 100-D Area, February/March 1993.

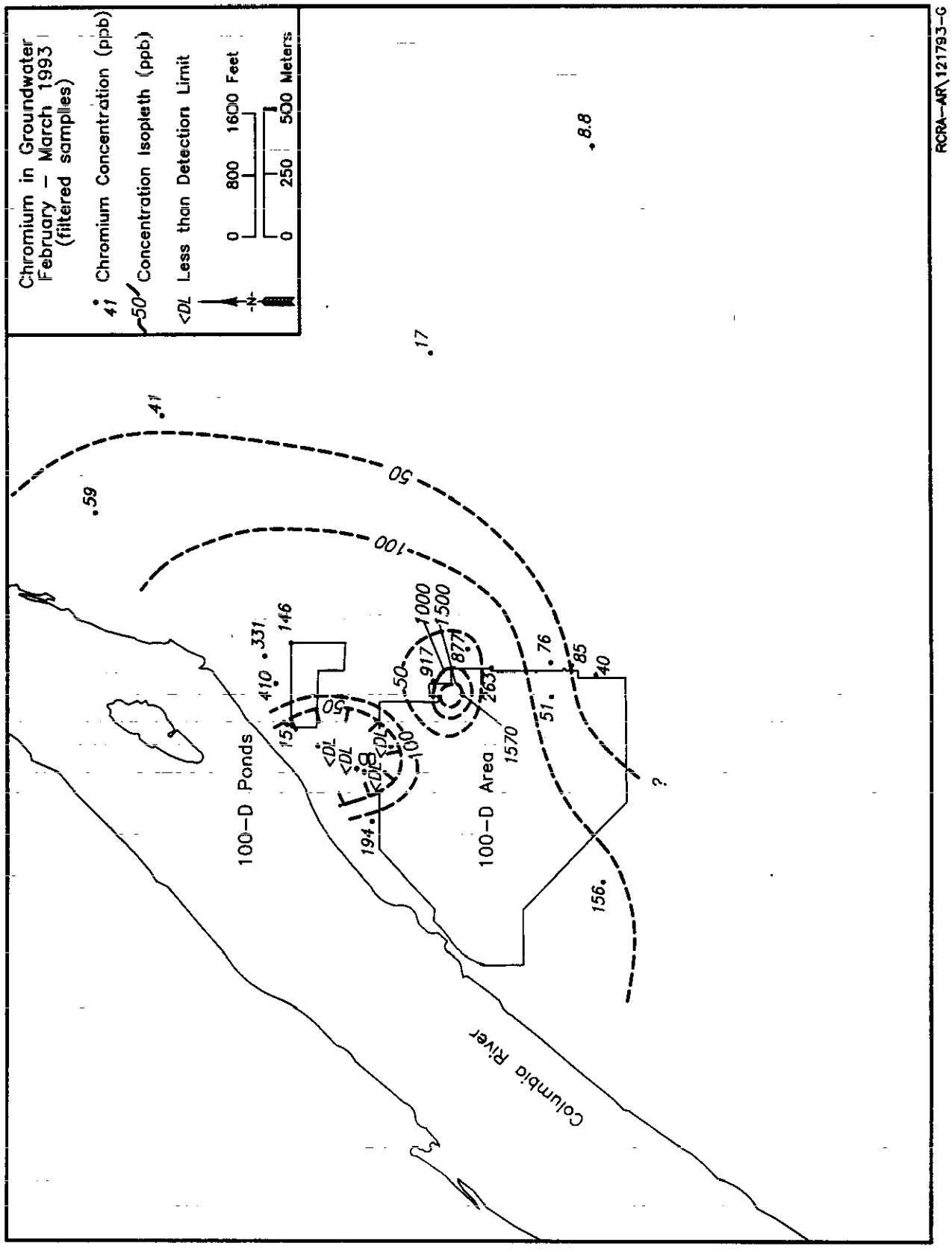


Figure 3.3-8. Tritium in the Uppermost Aquifer, 100-D Area, February/March 1993.

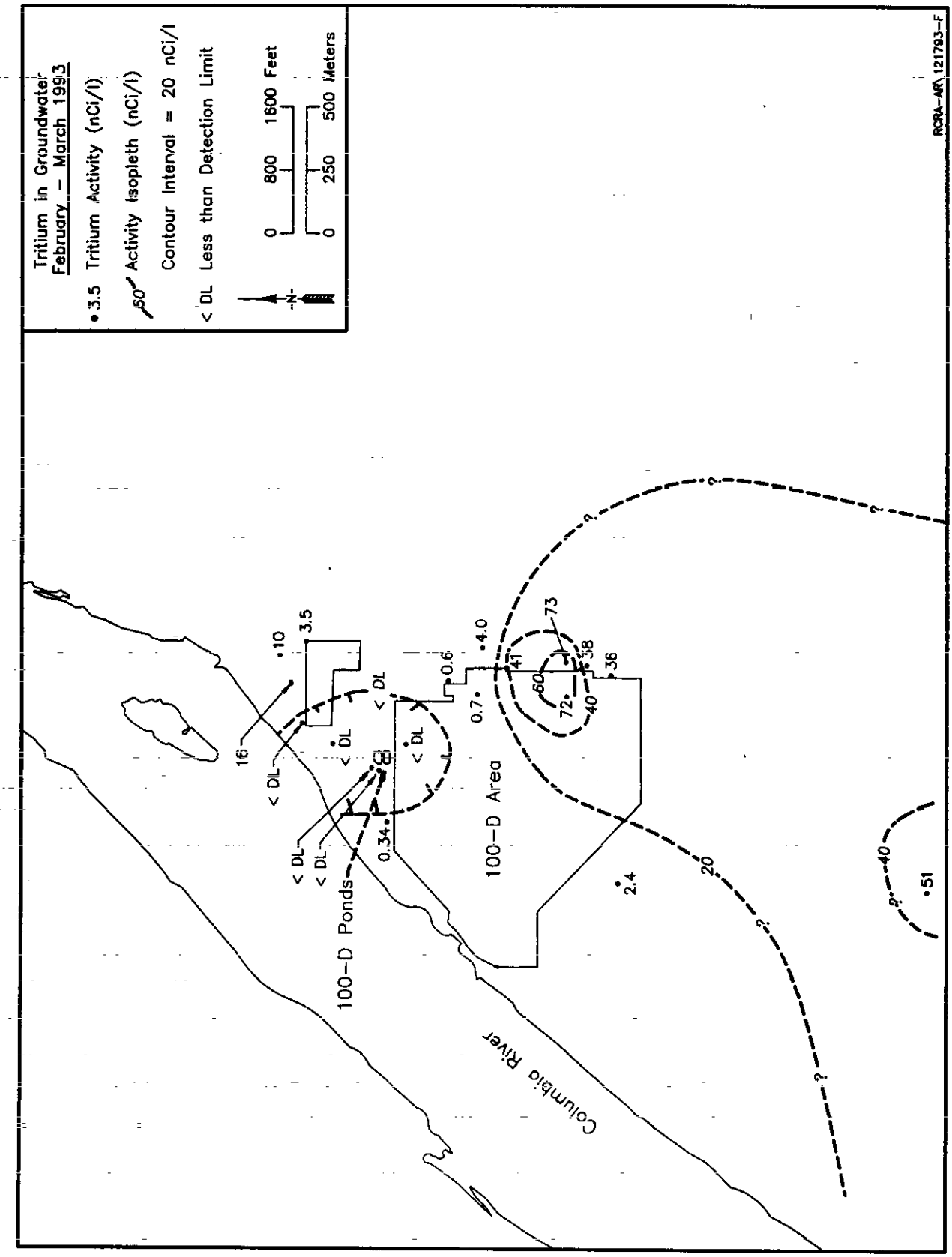


Table 3.3-3. Critical Means Table for 12 Comparisons--Background Contamination Indicator Parameter Data for the 100-D Ponds.[a,b]

Constituent (unit)	n	df	t_c	Average background	Standard deviation	Critical mean	Upgradient/ downgradient comparison value
Specific conductance (μmho/cm)	5	4	7.529	275.90	48.976	679.8	679.8
Field pH	5	4	9.029	8.070	0.101	[7.07, 9.07]	[7.07, 9.07]
Total organic carbon[c] (ppb)	5	4	7.529	500	NC	NC	800
Total organic halogen[d] (ppb)	NC	NC	NC	NC	NC	NC	NC

[a]Data collected from April 1992 to March 1993 for upgradient well 1-D5-13. Values calculated based on 12 comparisons.

[b]The following notations are used in this table:

df = degrees of freedom (n-1)

n = number of background replicate averages

t_c = Bonferroni critical t-value for appropriate df and 12 comparisons.

[c]Critical mean cannot be calculated because of the lack of an estimate of background standard deviation. The limit of quantitation (based on field blanks data, 1993) is used as the total organic carbon critical mean (see Appendix A).

[d]Critical mean cannot be calculated because of problems associated with data quality.

NC = not calculated.

generally the critical mean or critical range. The limit of quantitation is used as the comparison value for TOC instead of the critical mean because all the upgradient concentrations were below the contractually required quantitation limit (see Appendix C).

Specific conductance, pH, and TOC values for downgradient wells D8-4 and D8-6 were compared to the upgradient/downgradient comparison values. No downgradient values exceeded the comparison values. Well D8-5 will not be used for statistical comparisons, per agreement with the Washington State Department of Ecology, because it is located further from the unit.

3.3.6 Groundwater Flow

Water levels were measured in wells in and near the 100-D Area each month during the past year. The water table currently lies approximately 24 m (80 ft) beneath land surface at the 100-D Ponds, within Ringold Formation gravel. Interpretations of groundwater flow are based on water table maps constructed from the measured water levels.

3.3.6.1 Groundwater Flow Direction. Groundwater levels in the 100-D Area fluctuate with the stage of the Columbia River (Figure 3.3-9). Seasonal changes of up to 1 m (3 ft) were observed during the past year in the 100-D Ponds wells. When river stage is high, water levels in downgradient wells D8-4 and D8-6 can be slightly higher than in upgradient well D5-13.

Figure 3.3-10 shows the water table in the 100-D Area in May 1993 when the river stage was relatively high. The wells nearest the river (e.g., D8-53) had higher heads than wells further inland (e.g., D8-3), indicating that river water could flow into the aquifer. Groundwater beneath the 100-D Ponds at that time is inferred to flow parallel to the river, toward the northeast. By June 1993 the water table had reverted to its average position and groundwater flow was toward the river (toward the north and northwest) (Figure 3.3-11).

Vertical gradients are not well known in the 100-D Area. Only one well is completed below the top of the uppermost aquifer. Well D8-54B is completed in the first confined aquifer in the Ringold Formation, approximately 15 m (50 ft) below the bottom of the uppermost aquifer. Monthly water level measurements are inadequate to determine the vertical gradient between these two wells because of their rapid response to changes in river stage. There are recent transducer data for the two wells; measurements are recorded hourly. The data have not been fully evaluated but some preliminary conclusions may be drawn. The head in the deeper well, D8-54B, is consistently higher than the head in the shallower well, D8-54A, indicating an upward gradient. The difference in head varies from approximately 0.15 to 0.40 m (0.5 to 1.3 ft). The screen midpoints of the two wells are vertically 22.6 m (74 ft) apart. The upward gradient varies from 7×10^{-3} to 2×10^{-2}.

3.3.6.2 Rate of Flow. The water table is relatively flat between the upgradient and downgradient wells at the 100-D Ponds. The average gradient between wells D5-13 and D8-4 from October 1992 through September 1993 was 4×10^{-4}.

The rate of groundwater flow can be estimated by using a form of the Darcy equation with a range of input parameters.

$$v = \frac{Ki}{n_e} \qquad (1)$$

Figure 3.3-9. Water Level Versus Time in 100-D Pond Wells.

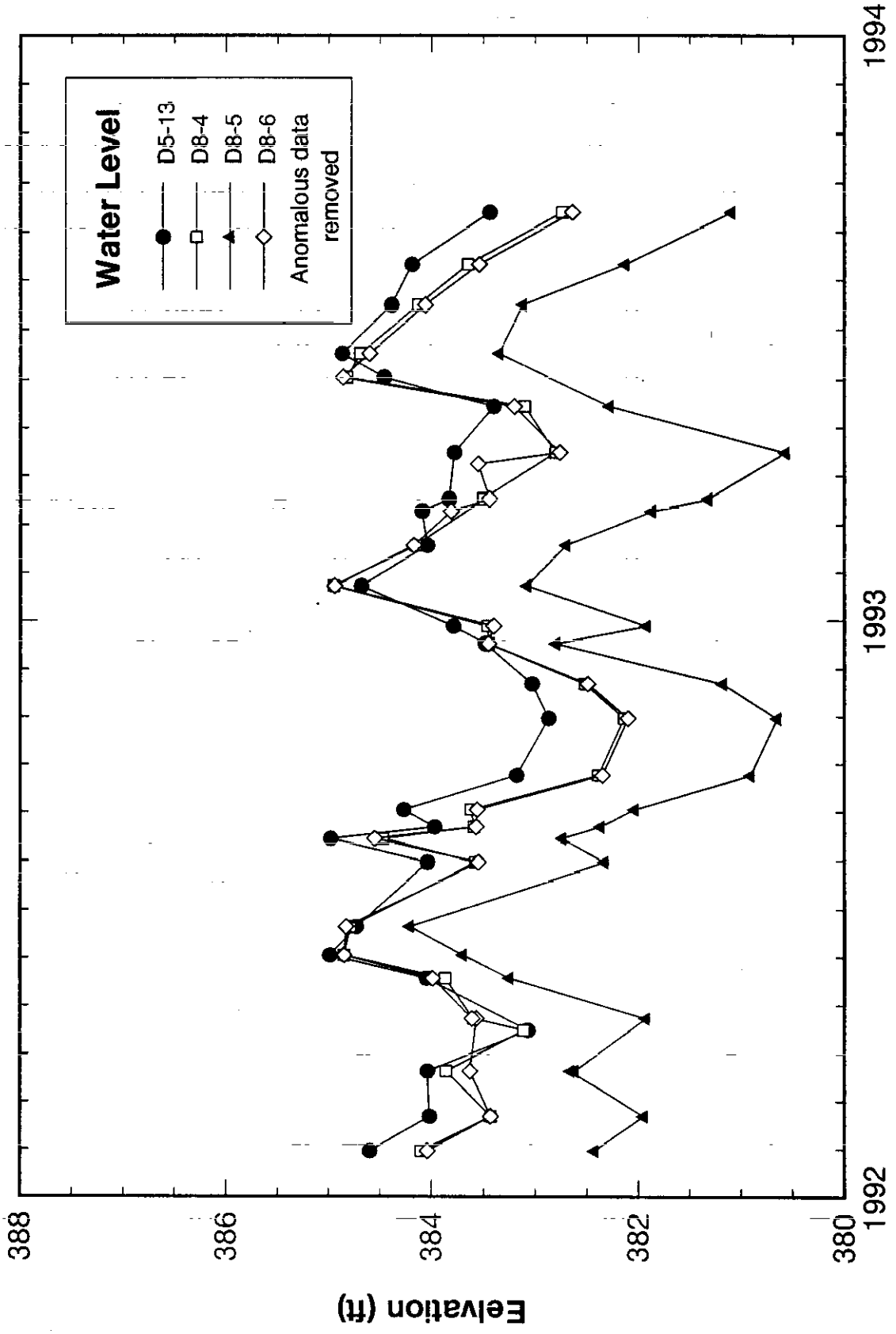
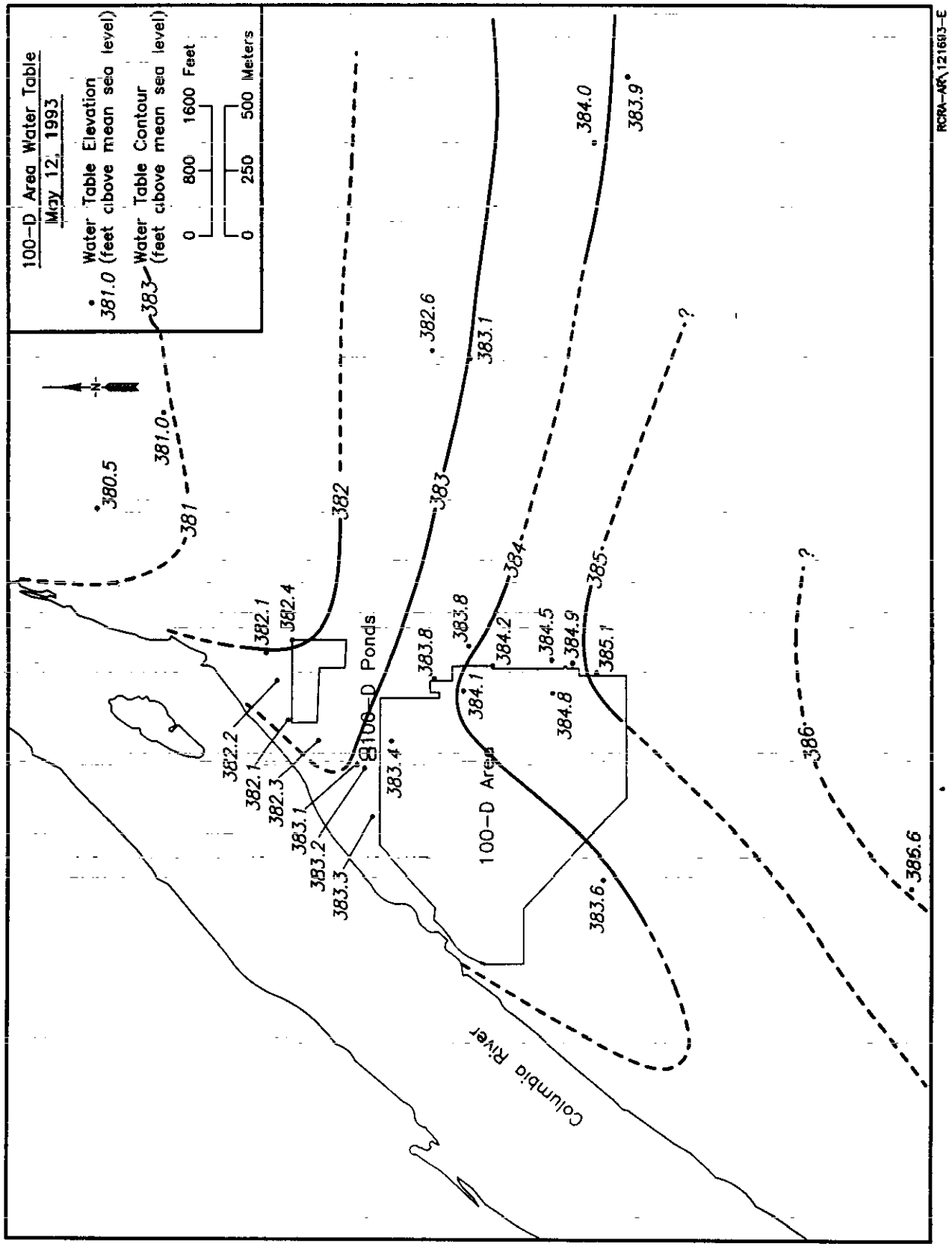


Figure 3.3-10. Water Table Map of the 100-D Area, May 1993.



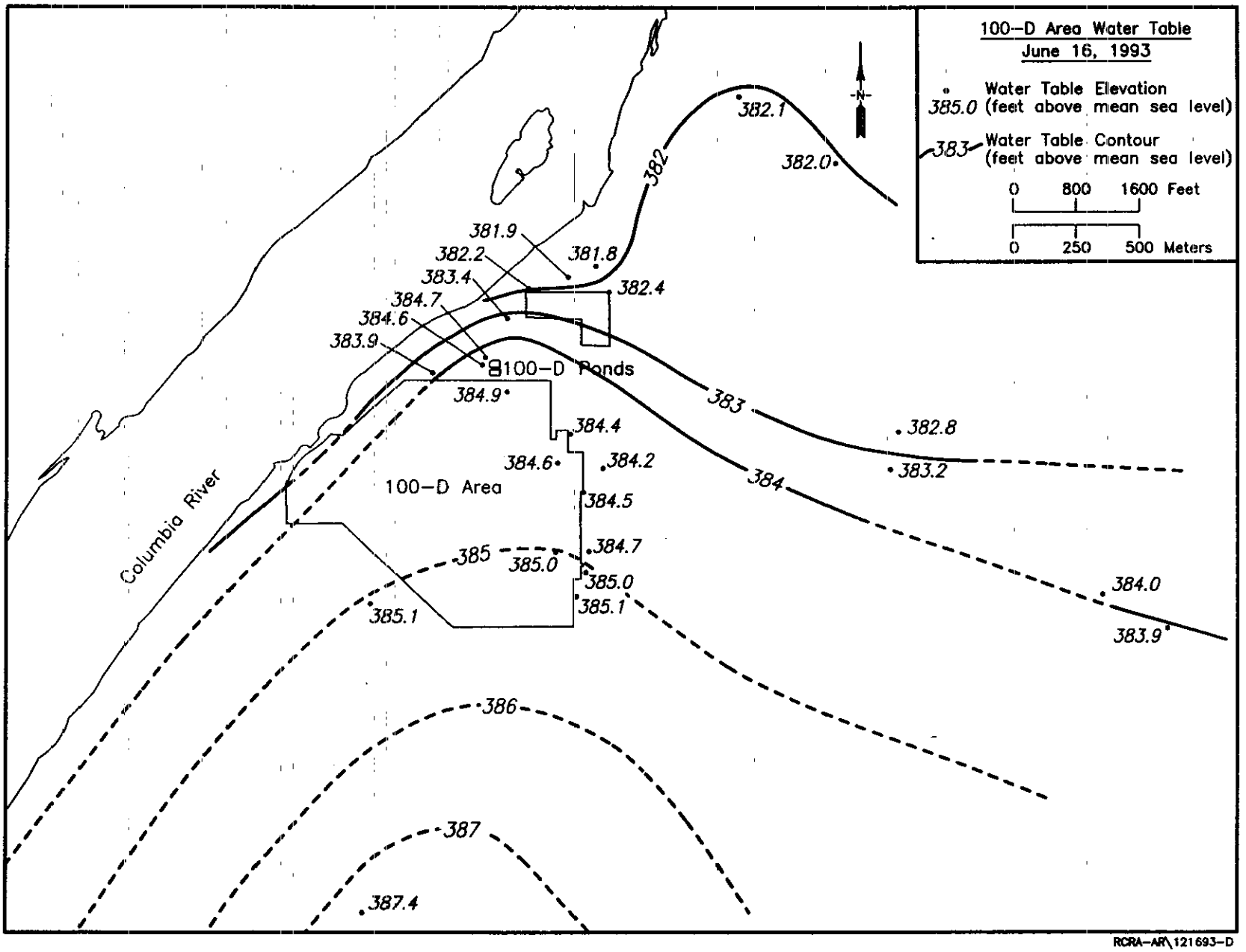


Figure 3.3-11. Water Table Map of the 100-D Area, June 1993.

where:

v = Average linear velocity of groundwater
K = Horizontal hydraulic conductivity
i = Hydraulic gradient
n_e = Effective porosity of the aquifer.

The following input parameters were used:

K = 1.2 to 40 m/d (3.9 to 130 ft/d) (slug withdrawal; Hartman 1992).
i = 4×10^{-4}
n_e = 0.1 to 0.3.

The resulting estimate of groundwater velocity ranges from 1.6×10^{-1} to 1.6×10^{-3} m/d (5×10^{-1} to 5×10^{-3} ft/d).

3.3.6.3 Evaluation of Monitoring Well Network. Groundwater flow has not changed significantly since the 100-D Ponds monitoring network was designed in 1991. The network is still considered adequate to detect contamination from the ponds.

3.3.7 References

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3.4 183-H SOLAR EVAPORATION BASINS

R. E. Peterson
Westinghouse Hanford Company

This report presents information gained during the fourth quarter of 1992 and the first three quarters of 1993 regarding hazardous waste constituents in groundwater beneath the 183-H Solar Evaporation Basins. Waste constituent indicators, along with their concentration, spatial distribution, and rate of migration, are described. The report supplements previous annual reports (Liikala 1988; Hall 1989a, 1990; Peterson 1991, 1992, 1993).

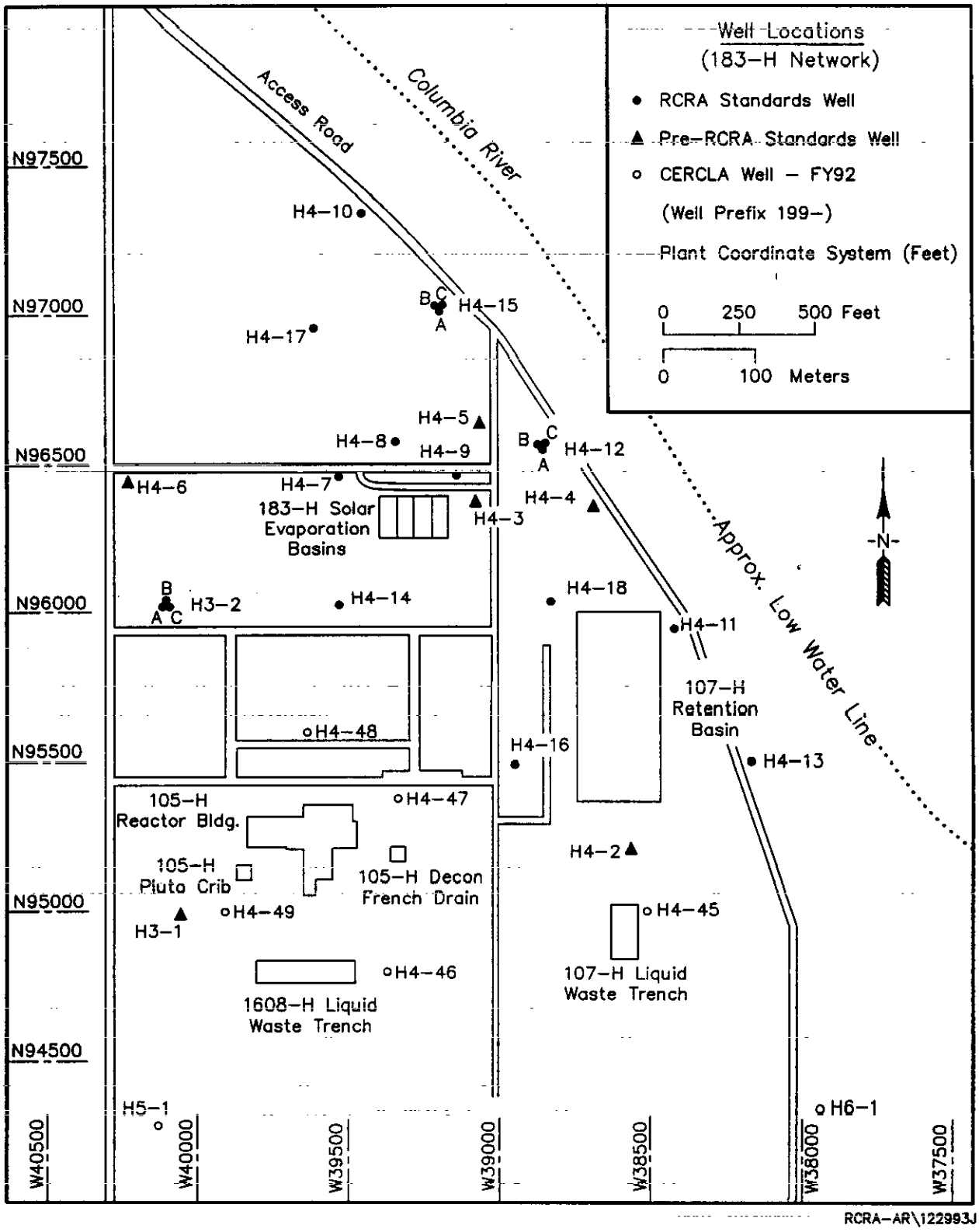
3.4.1 Facility Overview

The 183-H Solar Evaporation Basins are a *Resource Conservation and Recovery Act of 1976* (RCRA)-regulated treatment, storage, and/or disposal (TSD) facility. They are located beside the Columbia River in the northern portion of the Hanford Site (see Figure 1-1, Chapter 1.0). Originally, the concrete basins were part of a water treatment facility that provided coolant water to the 105-H Reactor, which was shut down in 1965. Between 1973 and 1985, they were used to store liquid wastes that resulted primarily from nuclear fuel fabrication activities conducted in the 300 Area. Volume reduction occurred by solar evaporation. The waste was predominantly acid etch solutions that had been neutralized with sodium hydroxide before being discharged into the basins (DOE-RL 1991a). The acid solutions included nitric, sulfuric, hydrofluoric, and chromic acids. The waste solutions, described as supersaturated, contained various metallic and radioactive constituents.

By the end of 1990, essentially all of the wastes had been removed from the basins and transported to the Hanford Site Central Waste Complex for interim storage. The concrete basin's interior surfaces have been partially decontaminated. An investigation has been completed to define the extent of contamination in the concrete and unsaturated soils beneath the basins. The results will be used to support decisions concerning final closure under RCRA. A description of the facility, history of operations, planned cleanup activities, and closure schedule are presented in DOE-RL (1991a).

Before the basins were used as a TSD facility in 1973, three groundwater monitoring wells existed in the 100-H Area. Well 199-H3-1 is located near the 105-H Reactor Building and is still used to monitor the unconfined aquifer at the water table. Well 199-H4-2 is located between the 107-H Retention Basin and the 107-H Liquid Waste Trench; it was drilled into basalt. During completion, the casing was perforated over a 7.6-m (25-ft) interval near the water table. With time, the seal at the deep end apparently failed. Subsequently, the water level in the well reached the surface and the well was capped in 1979. The well was reconfigured as a 5-cm- (2-in.-) diameter piezometer well in March 1993, as part of environmental restoration activities. It is screened between 113 and 118 m (371 and 386 ft) below the ground surface, and can be used to monitor the uppermost confined aquifer in

Figure 3.4-1. Monitoring Well Location Map for the 100-H Area.



basalt, which is presumed to be a flow top associated with the Elephant Mountain Member. A third well (199-H4-1) was located next to the 107-H Retention Basin on the basin's east side. It was used between 1952 and 1963 and then abandoned.

Limited groundwater monitoring was conducted during the operational life of the 183-H Solar Evaporation Basins, which spanned from 1973 to 1985. In 1974, a single downgradient well was installed near the eastern wall of the basins (199-H4-3). In 1983, two additional downgradient wells and one upgradient well were installed. In 1986 and 1987, 18 monitoring wells were installed in response to a *Consent Agreement and Compliance Order* entered into by the U.S. Department of Energy with the Washington State Department of Ecology and the U.S. Environmental Protection Agency (EPA) (Ecology and EPA 1986). These wells were built to RCRA standards and most monitor the unconfined aquifer at the water table. A groundwater monitoring plan was prepared to describe the installation of these wells (PNL 1986). An index map showing all existing wells in the 100-H Area is shown in Figure 3.4-1.

The current groundwater monitoring program is being conducted under interim-status regulations (40 *Code of Federal Regulations* [CFR] 265). It is an assessment level program (Para. 265.93[d]). The 183-H Solar Evaporation Basins are located within two *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA)-regulated operable units. Operable unit 100-HR-1 addresses surface sources of contamination and 100-HR-3 addresses groundwater contamination. Work plans for each of these operable units are available (DOE-RL 1991b and 1991c, respectively). If groundwater monitoring or remediation activities become part of RCRA closure requirements for the basins, those activities will be coordinated with environmental restoration activities under CERCLA.

A comprehensive description of 100-H Area stratigraphy is presented in Lindsey (1992 and 1993). Briefly, the uppermost portion of the unconfined aquifer in the 100-H Area resides in glacial flood deposits. The saturated portion of these deposits ranges in thickness from 2 to 6 m (6 to 18 ft) (Peterson and Connelly 1992). It consists of unconsolidated sands and gravels, referred to as the "Hanford formation." An erosional unconformity separates this hydrogeologic unit from the more consolidated fluvial sands and overbank deposits of the underlying Ringold Formation. The contrast in hydraulic conductivity across this unconformity, i.e., lower conductivity with increasing depth, acts as a barrier to downward migration of contaminants.

3.4.2 Summary of 1993 RCRA Activities

Routine monitoring of the groundwater plume attributable to 183-H Solar Evaporation Basins' waste continued during 1993. Quarterly sampling was conducted for most wells in the network. Three wells located near the basins on the downgradient side were sampled monthly to provide enhanced monitoring near the original source of contaminants. Monthly water level measurements were made in all wells in the 100-H Area. A noticeable increase in the concentrations of 183-H waste indicators in groundwater occurred during 1993. While the cause of this change is not fully understood, it is not believed to be the result of any activities within the basins or to the release of new effluents (see Section 3.4.5.1).

3.4.3 Other Activities in 1993

In addition to RCRA groundwater monitoring activities, several other groundwater investigations were underway during 1993 in the 100-H Area. Semiannual sampling of selected wells continued under the CERCLA remedial investigation for the 100-HR-3 operable unit. A limited field investigation report (DOE-RL 1993b) was completed that describes the initial results of the remedial investigation and a qualitative risk assessment for groundwater contamination.

Also, investigations to characterize the interaction between the Hanford Site unconfined aquifer and the Columbia River are being conducted in the 100-HR-3 operable unit. Hourly water level measurements are being obtained from eight wells and a river stage recorder to show the influence of daily and weekly river stage fluctuations on the water table (Campbell et al. 1993). Specific conductance and temperature are being recorded hourly at the 100-H Area river station, within a riverbank seepage area (seep #153-1), and at nearby well 199-H4-11. The latter data clearly reveal the influence of bank storage of river water on groundwater quality within the first several hundred feet of the shoreline. Samples of riverbank seepage were obtained from several locations along the 100-H shoreline and analyzed for hazardous waste indicators. Nearshore sediment samples were collected and analyzed also.

3.4.4 Sampling and Analysis Program

The initial RCRA groundwater monitoring plan for the 183-H Basins was prepared by Pacific Northwest Laboratory (PNL 1986). Subsequent changes to the monitoring activities are described in quarterly and annual RCRA reports (see Chapter 1.0 for a full list of available reports), in the closure plan for the facility (DOE-RL 1991a), and in annual statements of work to PNL for sampling and analysis support.

3.4.4.1 Monitoring Well Network. Currently 31 groundwater monitoring wells are available for use in the 100-H Area (see Figure 3.4-1). Twenty-three of these wells are within the groundwater flow path that is pertinent to monitoring contamination from the basins. Table 3.4-1 summarizes the characteristics and RCRA sampling schedules for these wells. Many are jointly used by other programs, including the 100-HR-3 remedial investigation and the Sitewide Environmental Surveillance program.

Most of these wells are constructed to RCRA standards with stainless steel casings and screens, annular seals, and protective pads around the surface casing. Several wells were constructed before the adoption of RCRA standards and have carbon steel casings with either a perforated or screened open interval. The pre-RCRA standards wells have no annular seal and did not have a protective pad at the surface until 1987. They include wells 199-H3-1, 199-H4-3, 199-H4-4, 199-H4-5, and 199-H4-6. The "B" and "C" series wells monitor relatively deeper levels in the unconfined aquifer. All network wells have dedicated HydroStar[1] pumps for purging and collecting samples.

[1]HydroStar is a trademark of Instrumentation Northwest Incorporated.

Table 3.4-1. Monitoring Wells in 183-H Solar Evaporation Basins Network.

Well no. (199-)	Hydrologic unit monitored	Sampling frequency[a]	Well standards	Other networks
H3-1[1960]	Top of unconfined	Annually	PRE	HR3, SES
H3-2A[1986]	Top of unconfined	Quarterly	RCRA	SES
H3-2B[1986]	Top of unconfined	Annually	RCRA	SES
H3-2C[1986]	Mid-depth unconfined	Quarterly	RCRA	--
H4-10[1986]	Top of unconfined	Annually	RCRA	HR3
H4-11[1986]	Top of unconfined	Quarterly	RCRA	--
H4-12A[1986]	Top of unconfined	Quarterly	RCRA	SES
H4-12B[1986]	Top of unconfined	Annually	RCRA	SES
H4-12C[1986]	Mid-depth unconfined	Quarterly	RCRA	SES
H4-13[1986]	Top of unconfined	Annually	RCRA	HR3
H4-14[1986]	Top of unconfined	Quarterly	RCRA	--
H4-15A[1986]	Top of unconfined	Quarterly	RCRA	HR3
H4-15B[1986]	Top of unconfined	Annually	RCRA	SES
H4-15Cq[1986]	Bottom of unconfined	NS	RCRA	--
H4-15Cr[1986]	Mid-depth unconfined	NS	RCRA	--
H4-15Cs[1986]	Mid-depth unconfined	NS	RCRA	--
H4-16[1987]	Top of unconfined	Annually	RCRA	HR3, SES
H4-17[1987]	Top of unconfined	Annually	RCRA	HR3, SES
H4-18[1987]	Top of unconfined	Quarterly	RCRA	SES
H4-3[1974]	Top of unconfined	Monthly	PRE	--
H4-4[1983]	Top of unconfined	Monthly	PRE	SES, DOH
H4-5[1983]	Top of unconfined	Quarterly	PRE	--
H4-6[1983]	Top of unconfined	Quarterly	PRE	--
H4-7[1986]	Top of unconfined	Quarterly	RCRA	SES
H4-8[1986]	Top of unconfined	Quarterly	RCRA	SES
H4-9[1986]	Top of unconfined	Monthly	RCRA	SES

Notes: Superscript following well number denotes year installed.
Shading denotes upgradient well.
[a]Water levels are measured monthly in all wells.
DOH = Washington State Department of Health.
HR3 = 100-HR-3 groundwater operable unit.
NS = not sampled (piezometer).
PRE = constructed before RCRA standards.
RCRA = in compliance with RCRA construction standards.
SES = Sitewide Environmental Surveillance Program (Bisping 1993).

3.4.4.2 Sampling and Analysis Schedule. The sampling schedule for the network includes quarterly sampling of wells that are used to define the extent of contamination and upgradient conditions. Additionally, monthly sampling is conducted in selected wells located immediately downgradient of the basins to provide enhanced monitoring during final decontamination and closure activities. Annual sampling of wells in the vicinity of the basins, but not directly in the flowpath under the basins, is conducted to provide 100-H Area baseline data. The constituent list for samples collected is summarized in Table 3.4-2.

Water levels are measured using a steel tape at monthly intervals. Water levels also are recorded whenever a well is sampled. A river stage recorder and several well transducer/data logger installations, which are operated under the CERCLA program, provide water level measurements at 1-hour intervals. The data from these efforts are used to help explain the temporal variability observed in 100-H Area groundwater quality, particularly in wells near the river. They can also be useful in helping to determine the transport of contaminants in groundwater toward the river.

3.4.5 Groundwater Chemistry

Indicators for 183-H Basins waste constituents in groundwater include nitrate, sulfate, sodium, gross alpha, and gross beta. As described in the facility closure plan (DOE-RL 1991a, pp. I-8 to I-10), nitrate and sulfate ions represent the largest amounts, by weight, of routine waste discharged to the basins. Sodium was common in the waste because the acid solutions discharged to the basins were neutralized with sodium hydroxide. Both uranium and technetium were present in the waste; they are the presumed source for gross alpha and beta activities, respectively. Chromium used to be a fairly good indicator in groundwater when contamination levels were higher than present levels. It currently does not help to define the 183-H Basins' plume because it is masked by a more widespread chromium plume that apparently has multiple sources (Liikala et al. 1988, pp. 125 and 146).

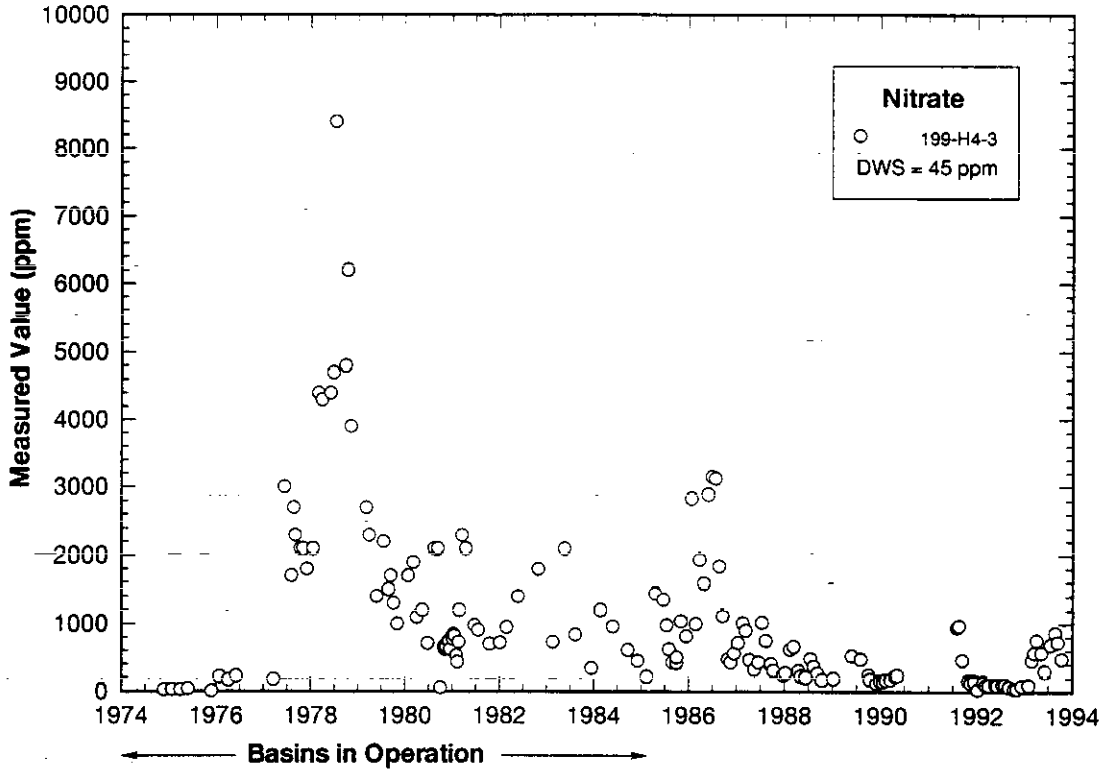
3.4.5.1 Concentration Histories of Waste Indicators. Well 199-H4-3 was the only well available to monitor operations at the basins during their period of active use, which was from 1974 to 1985. Water samples were obtained fairly regularly from the well and a limited suite of analyses were run on the samples. Waste indicator constituent concentrations for this well, grouped by anions, metals, and radioactivity (Figures 3.4-2 through 3.4-4), reveal several significant features. The high levels for these constituents during 1978 are assumed to have resulted from leakage from Basin #1. Waste was subsequently transferred from that basin to adjacent basins, whose integrity had been improved by the addition of various liners to their concrete walls. A second peak is apparent during 1986 (see Figure 3.4-2) and was probably associated with cleanup activities in Basin #1.

Table 3.4-2. Constituent List for the 183-H Solar Evaporation Basins.

EPA Interim Primary Drinking Water Standards (265.92[b][1], App. III)		
Arsenic[a]	Nitrate	2,4-D[a]
Barium	Selenium[a]	2,4,5-TP Silvex[a]
Cadmium	Silver	Radium[a]
Chromium	Endrin[a]	Gross alpha
Fluoride	Lindane[a]	Gross beta
Lead[a]	Methoxychlor[a]	Turbidity[b]
Mercury[a]	Toxaphene[a]	Coliform bacteria[a]
Groundwater Quality Parameters (265.92[b][2])		
Chloride	Manganese	Sodium
Iron	Phenols[a]	Sulfate
Contamination Indicator Parameters (265.92[b][3])		
pH	Total organic carbon	
Specific conductance	Total organic halogen	
Site-Specific Hazardous Waste Indicators (265.93[d][3][ii])		
Chromium	Nickel	Technetium-99
Copper	Nitrate[c]	Uranium
Fluoride	Sodium[c]	Gross alpha[c]
Manganese	Sulfate	Gross beta[c]

[a]Not detected from 1985 to 1989. No longer included in quarterly assessment of plume.
[b]Only required for surface water bodies.
[c]Best current indicators to define plume.

Figure 3.4-2. Nitrate and Sulfate Concentrations in Well 199-H4-3.



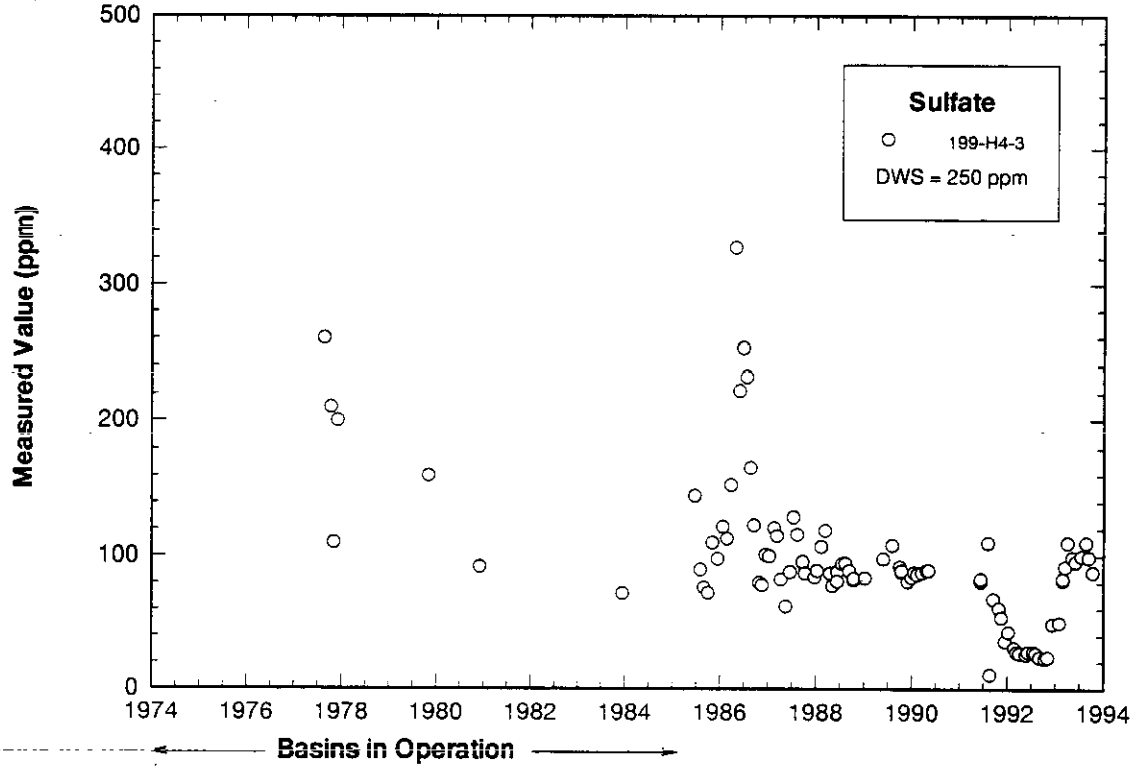
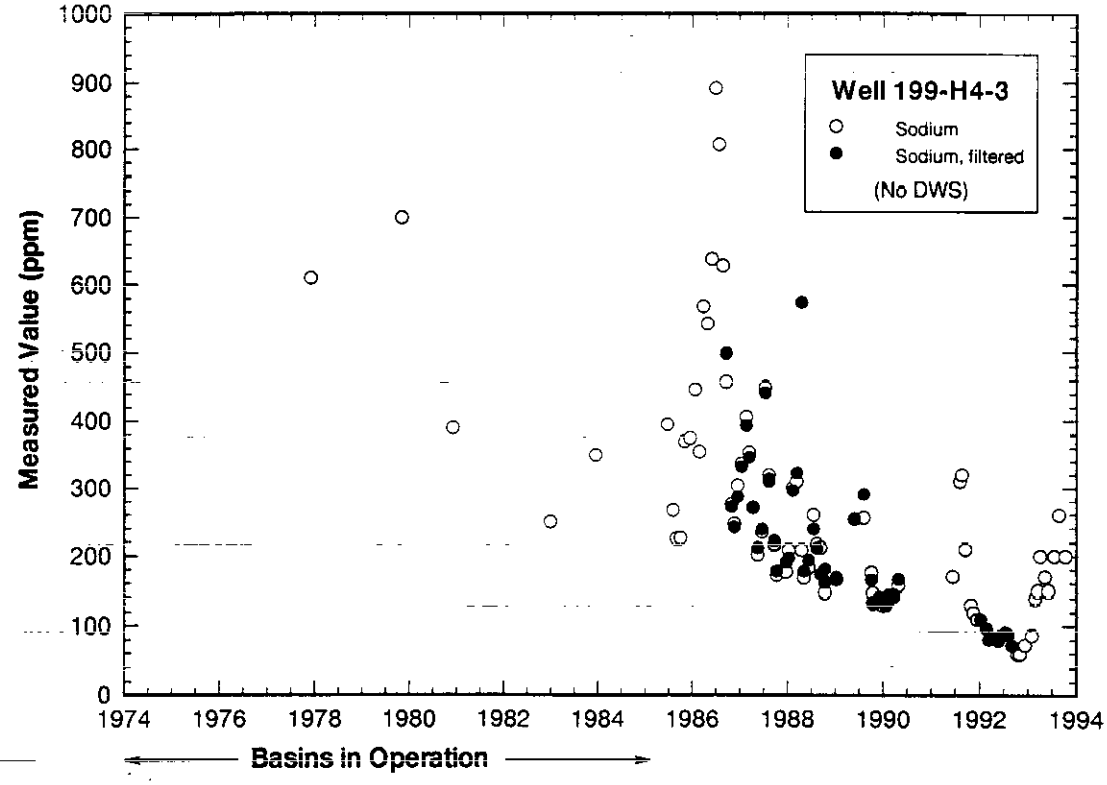


Figure 3.4-3. Sodium and Chromium Concentrations in Well 199-H4-3.



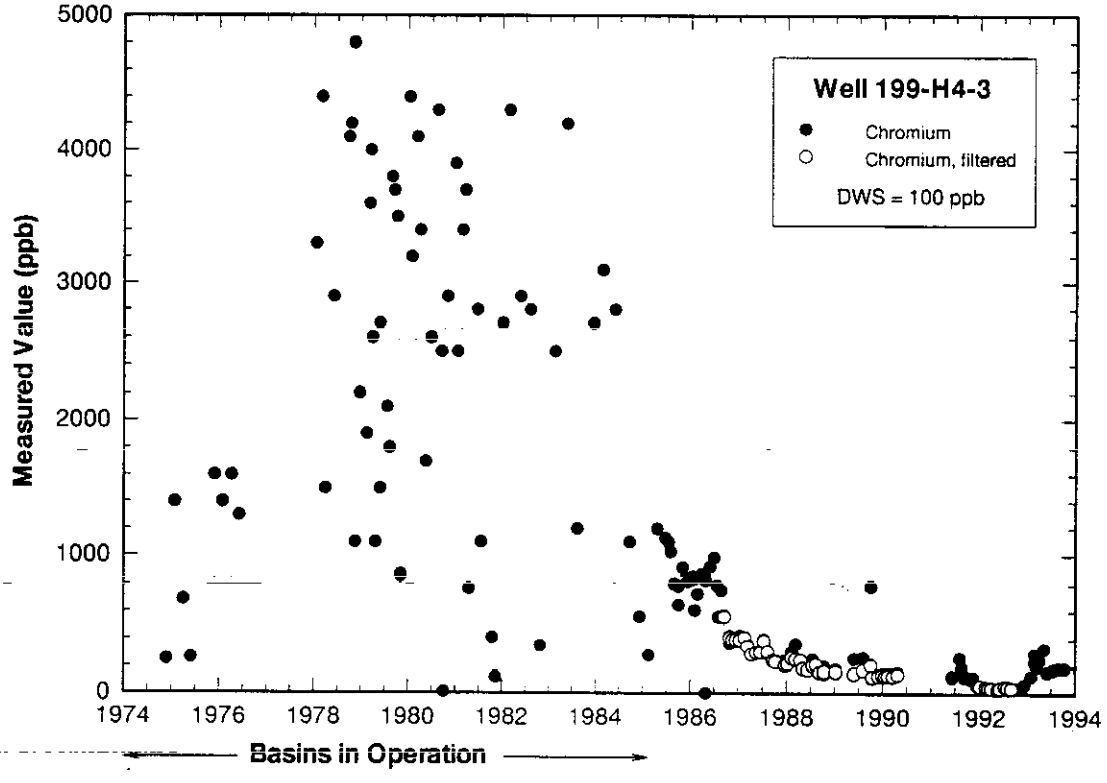
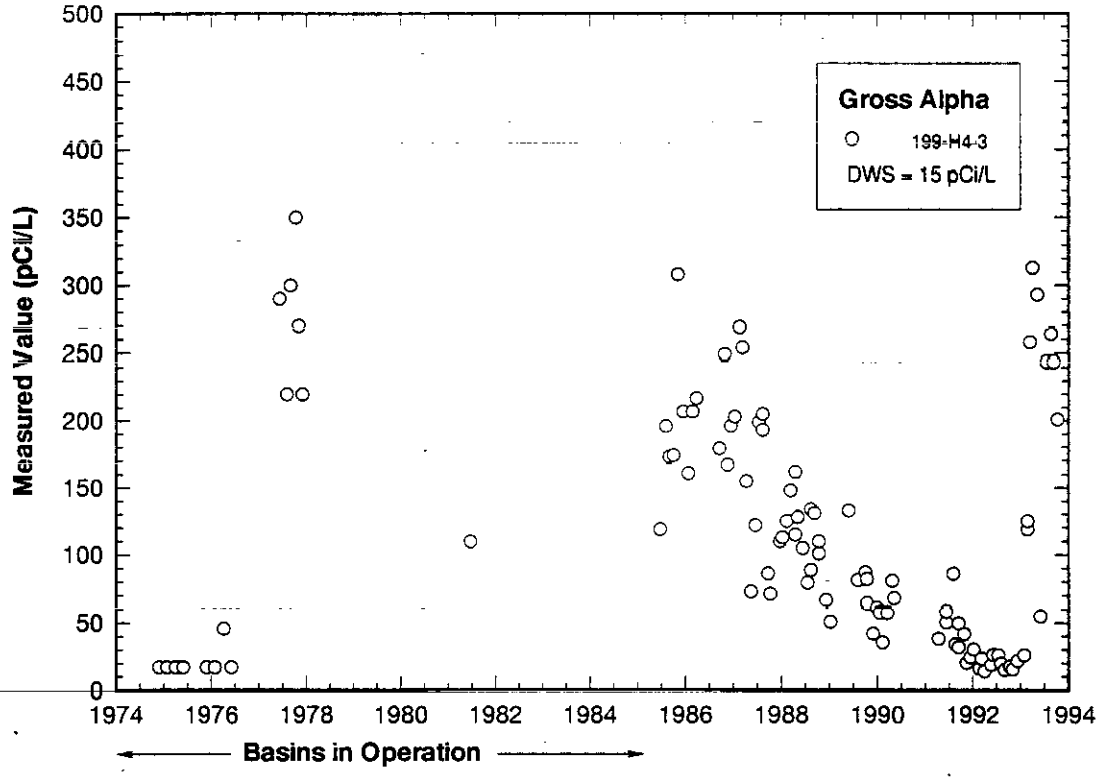
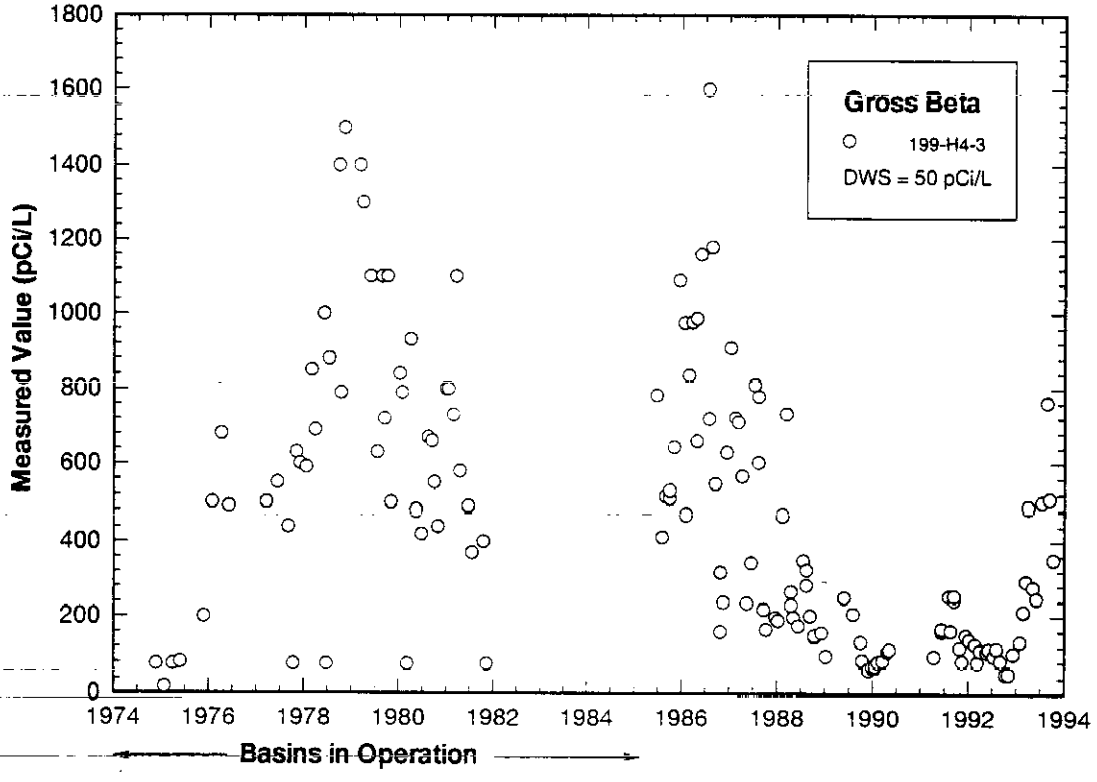


Figure 3.4-4. Gross Alpha and Gross Beta Concentrations in Well 199-H4-3.





In recent years, groundwater concentrations of the various waste indicators have steadily declined since the peaks of 1986, with several exceptions. During the last half of 1990 and first half of 1991, the sampling and analysis program was interrupted by analytical laboratory problems. When sampling resumed, concentrations of waste indicators in wells within the contaminant plume were higher than the previously established trends. The cause for this may have been an atypically high water table during that period (Peterson 1993, pp. 3-3 and 3-4).

During 1993, concentrations of site-specific waste indicators exhibited a distinct increase in three of the four wells that intercept the plume. Figures 3.4-5 through 3.4-7 illustrate these changes for 183-H waste indicators. These increases do not occur simultaneously in the plume wells, but appear first in well 199-H4-3 and progress to well 199-H4-9, then on to well 199-H4-4, which is located several hundred feet downgradient of well 199-H4-3.

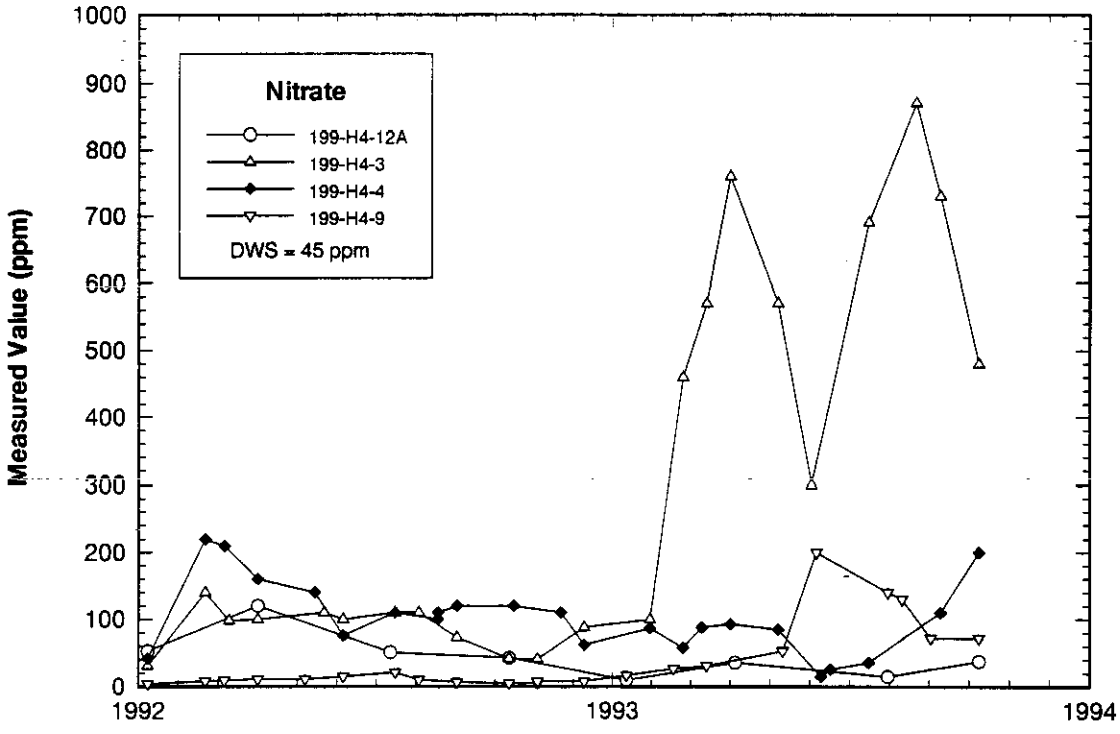
The cause for the increases in waste indicators is not apparent. No known activities were conducted in or around the basins during 1993 that would have released liquid effluent to the soil column. The changes are most noticeable in well 199-H4-3, which is adjacent to the basins on the downgradient side. Chemical and radiological constituents are summarized for this well in Figure 3.4-8.

While previous changes in indicator concentrations in plume wells appear to be related to a fluctuating water table (Peterson 1990), that does not explain the current changes. Turbidity has increased in many network wells during 1993 and the timing of this change correlates with the increased concentrations of waste indicators. Figure 3.4-9 illustrates the correlation between the onset of increases in waste indicator constituents and turbidity, and the absence of correlation between constituent changes and water level changes. Also, the spatial distribution of turbidity does not correspond to the inferred extent of the 183-H plume, so turbidity by itself does not provide a complete explanation.

However, whatever is causing the increased turbidity may also be causing the increases in waste indicators. Turbidity could be the result of excessive pumping rates to purge the well before sampling, although field records do not suggest that this has occurred. Breakthrough of fine-grained particles that have accumulated in the sand pack around the well screen may be occurring, indicating the need for redevelopment of the well. Either of these mechanisms would explain elevated metals and radionuclides in unfiltered samples, but wouldn't necessarily result in elevated dissolved constituents that aren't associated with particulates, such as nitrate and sulfate.

The cause for these changes in water quality near the 183-H Basins is still under investigation. It is not thought to be related to basin operations.

Figure 3.4-5. Nitrate and Sulfate in 183-H Basins Plume Wells.



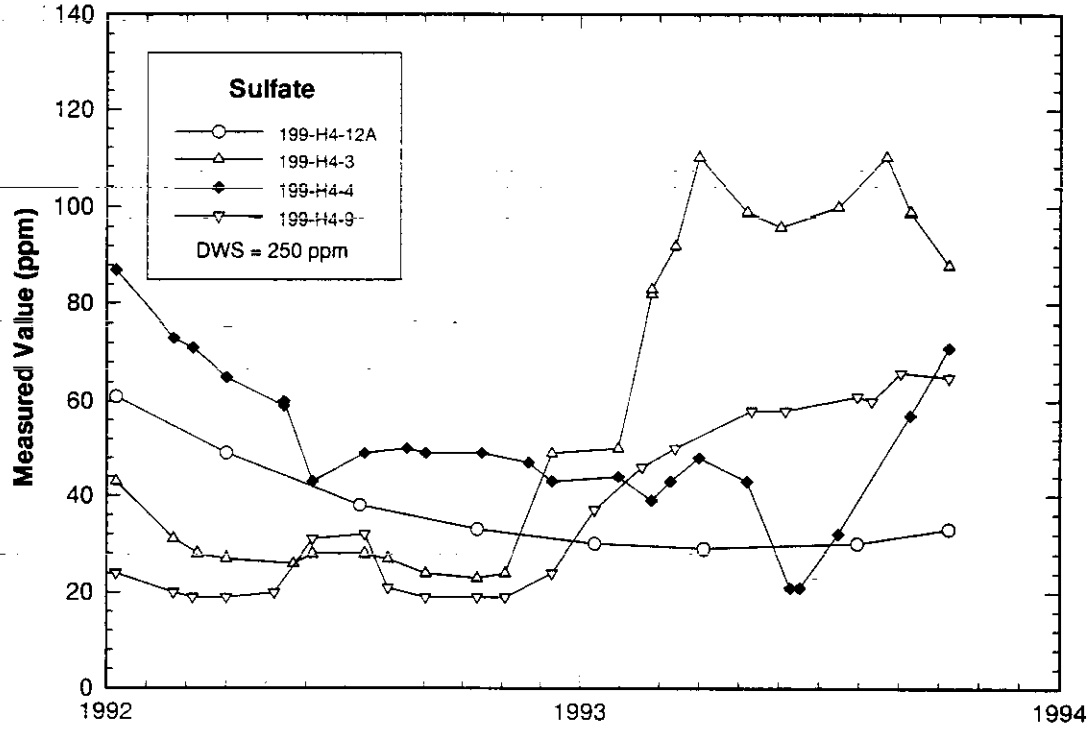


Figure 3.4-6. Sodium and Chromium in 183-H Basins Plume Wells.

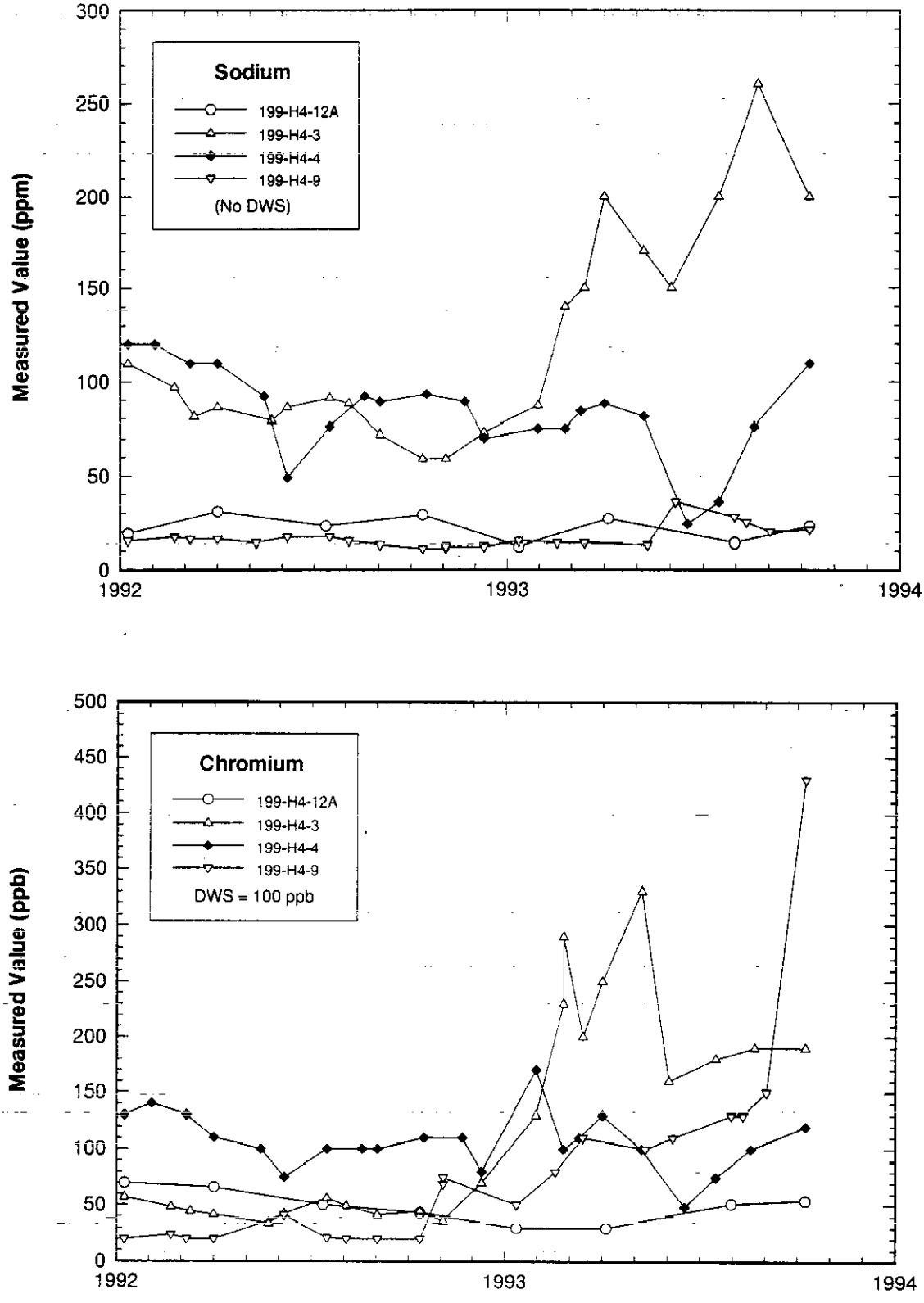
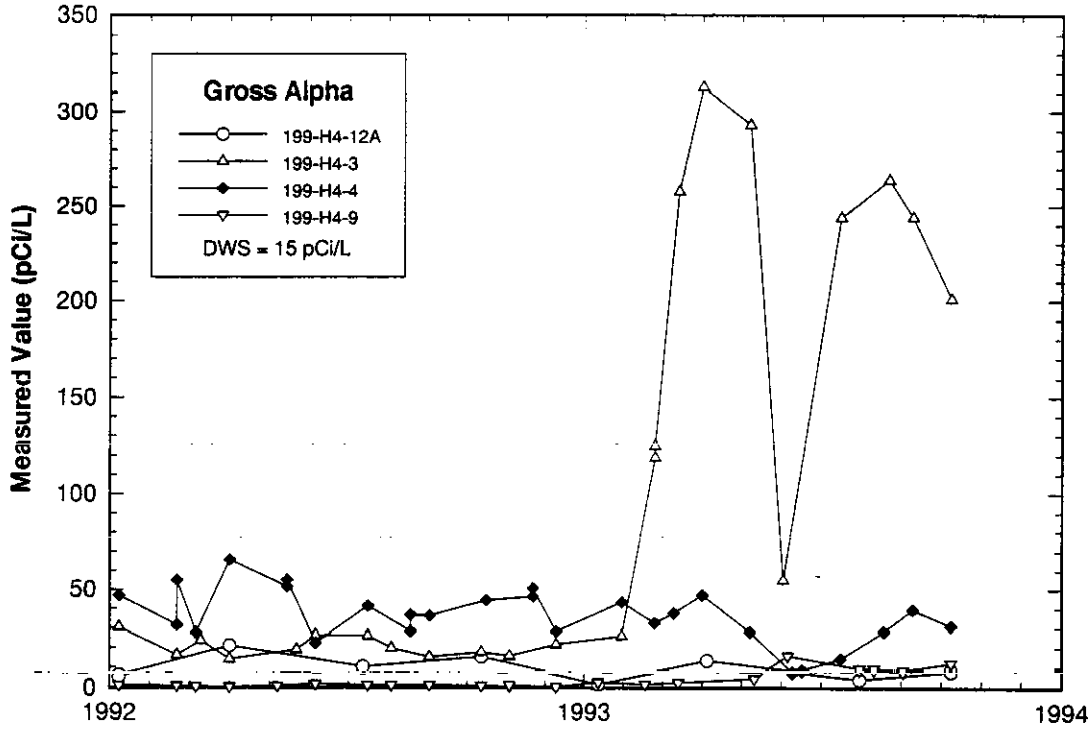


Figure 3.4-7. Gross Alpha and Gross Beta in 183-H Basins Plume Wells.



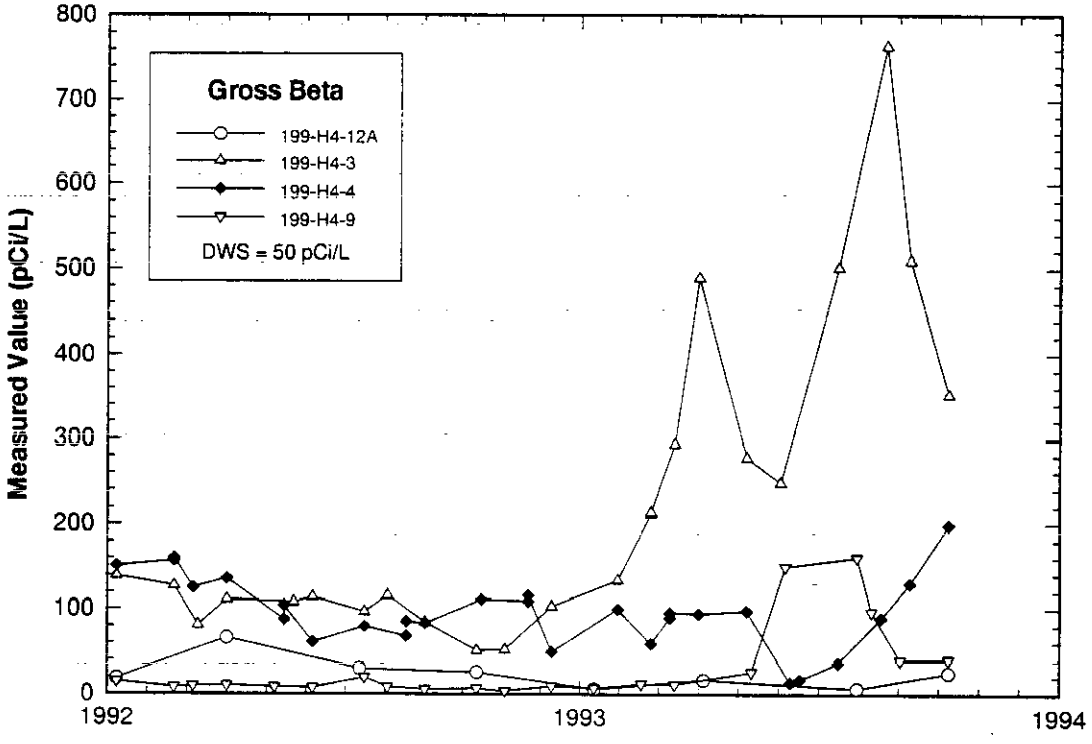
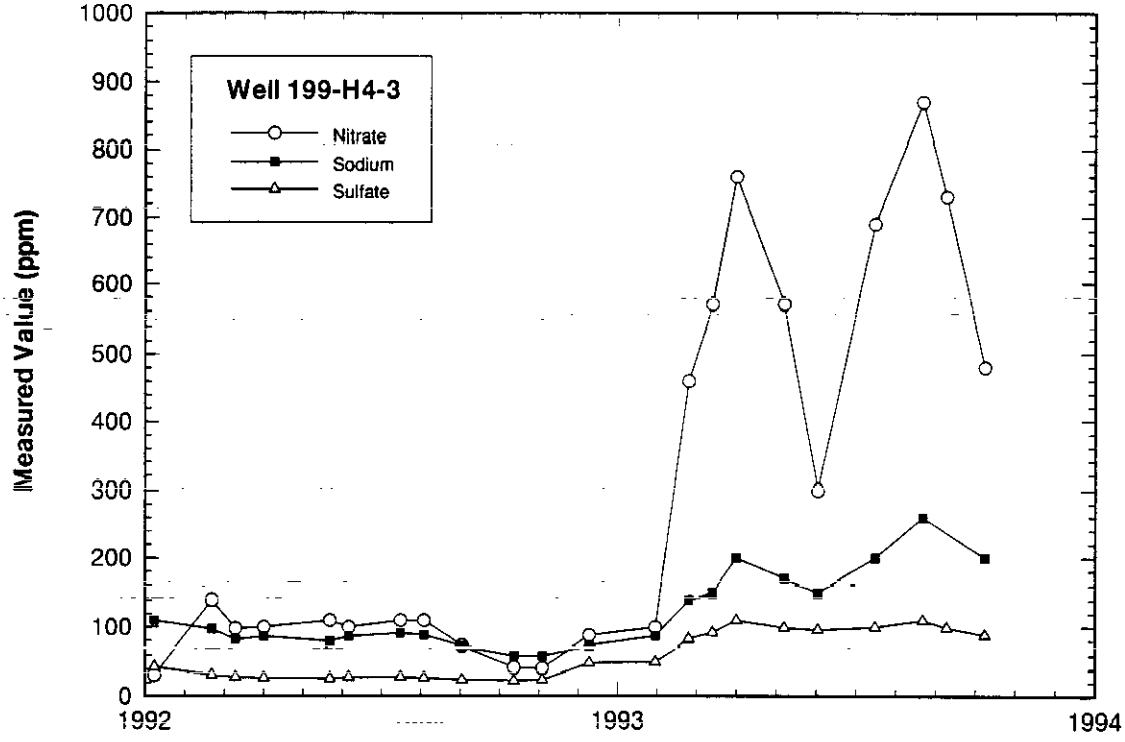


Figure 3.4-8. Recent Chemical and Radiological Changes in Well 199-H4-3.



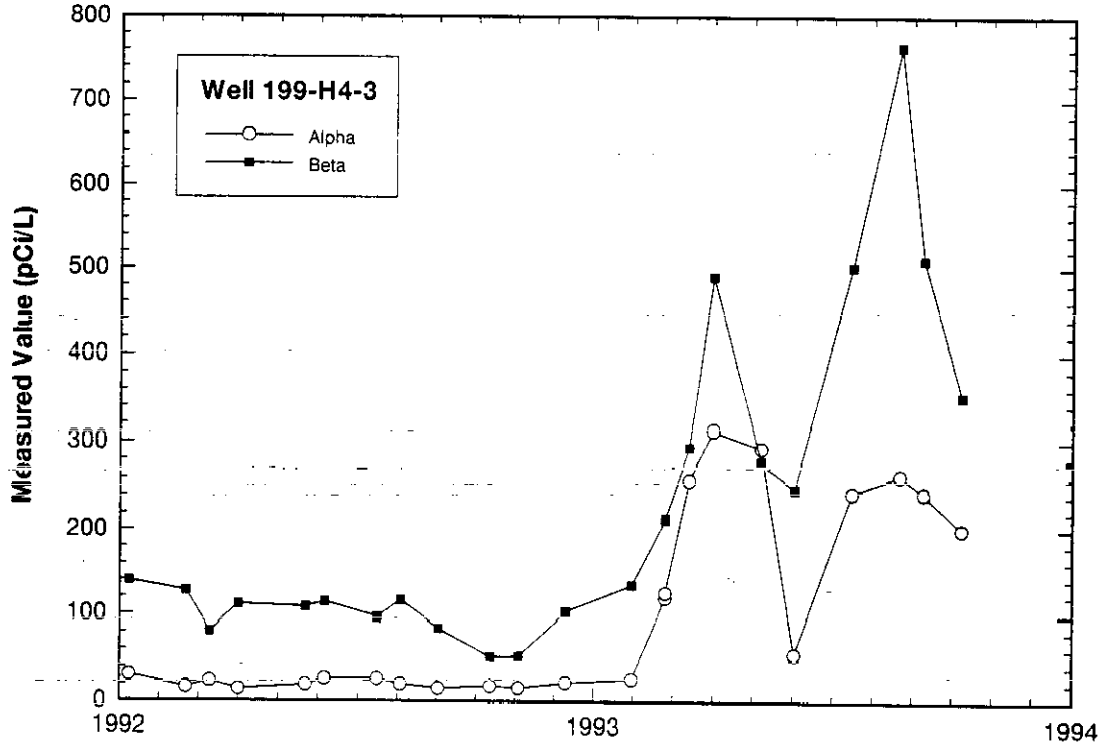
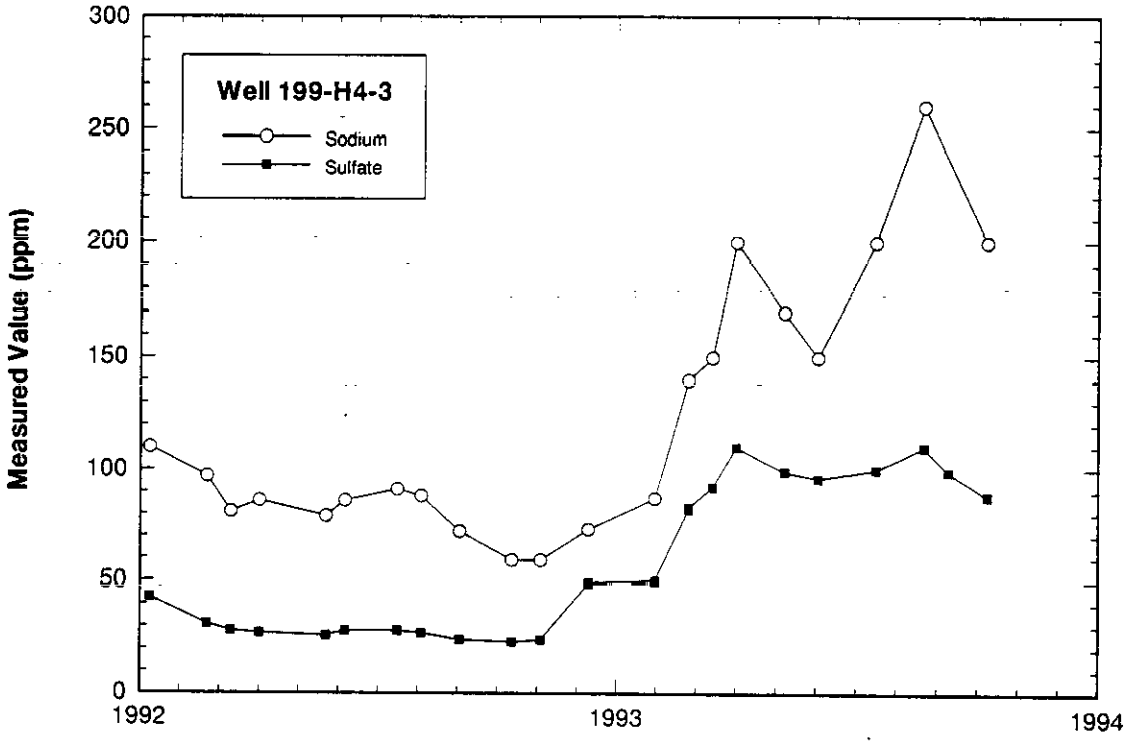


Figure 3.4-9. Waste Indicators, Turbidity, and Water Levels in Well 199-H4-3. (sheet 1 of 2)



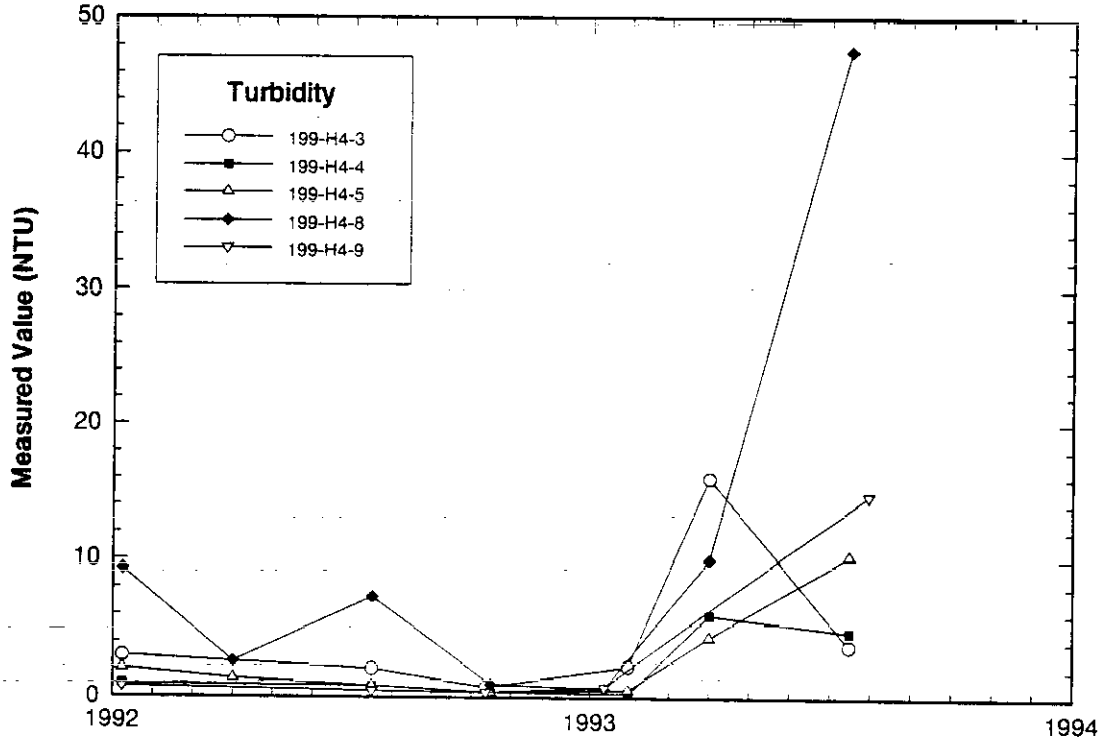
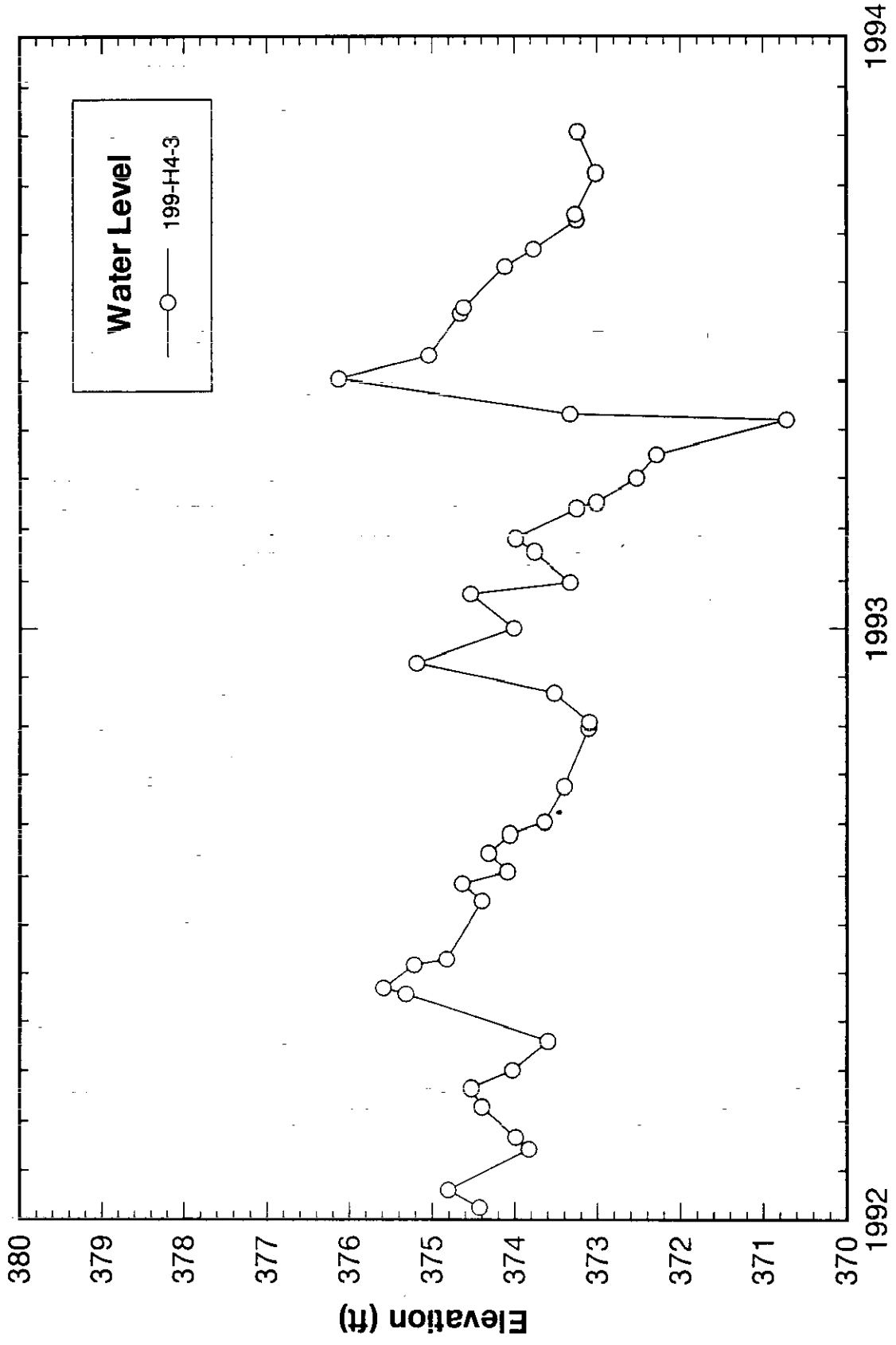


Figure 3.4-9. Waste Indicators, Turbidity, and Water Levels in Well 199-H4-3. (sheet 2 of 2)



3.4.5.2 Distribution of Waste Constituents. Maps showing the concentrations of key waste indicators, i.e., nitrate, sulfate, sodium, gross alpha, and gross beta, are presented in Figures 3.4-10 through 3.4-14 to illustrate July 1993 conditions. While several wells adjacent to the basins are elevated in these waste indicators, a well-defined plume is more difficult to discern. Consequently, a dashed line is used to show the inferred extent of the 183-H plume, based on previously defined plume boundaries, because recent increases in waste indicator concentrations have made contouring values somewhat uncertain with regard to current plume boundaries (see Section 3.4.5.1). Wells 199-H4-3, 199-H4-4, 199-H4-9, and 199-H4-12A have been described previously as intersecting the plume (Peterson 1993) and the dashed line on the maps is based on previously drawn plume boundaries. Distribution data for 1993 suggest that well 199-H4-18 may now be influenced by the plume also.

The distribution of chromium in 100-H Area groundwater is shown in Figure 3.4-15. This chromium has several potential sources, including 183-H Basins waste. A description of the chromium plume in 100-H Area groundwater is presented in Peterson and Connelly (1992). Their three-dimensional model suggests that the volume of water containing chromium above 10 ppb is roughly 500,000 m^3 (132,000,000 gal). The mass of chromium contained in that volume is approximately 40 kg (90 lb). Relative to the EPA drinking water standard of 100 ppb, the volume of water affected is roughly 200,000 m^3 (53,000,000 gal), and the mass approximately 25 kg (55 lb).

Peterson and Connelly (1992) ran volume and mass calculations for data sets representing 1988, 1990, and 1992 conditions. The results show a slight increase with time for both the volume of water affected and the mass of chromium contained in the plume. They offer three possible explanations. First, residual chromium held on the soil column may have been remobilized during the relatively high water tables that were present during 1990 and 1991. Second, chromium-bearing groundwater from the west or northwest appears to be migrating into the 100-H Area. Finally, an unknown source of chromium, such as buried piping or storage tanks, may be continuing to add to the plume.

Turbidity measurements for July were also plotted in an attempt to explain the rise in waste indicator constituents that occurred during 1993 (Figure 3.4-16). Elevated turbidity in the well network does not correlate with the 183-H groundwater plume. However, whatever is causing an increase in turbidity in 100-H Area wells may also be the explanation for the 1993 increases in waste indicator concentrations (see Section 3.4.5.1).

To date, no conclusive evidence for downward migration of 183-H Basins waste constituents within the unconfined aquifer has been found. Two clusters of wells, which are sampled at three different depths, are used to confirm that 183-H waste constituents are not migrating downward. Three-well clusters at upgradient well 199-H3-2 and downgradient well 199-H4-12 each have a well screened at the water table (designated A), just below the Hanford/Ringold contact (B), and at mid-depth in the Ringold Formation (C). A third cluster at well 199-H4-15 has completions at similar depths (A) and (B); however, well 199-H4-15C contains multiple piezometer tubes that are used only for water level measurements.

Figure 3.4-10. Nitrate Distribution Near the 183-H Basins, July 1993.

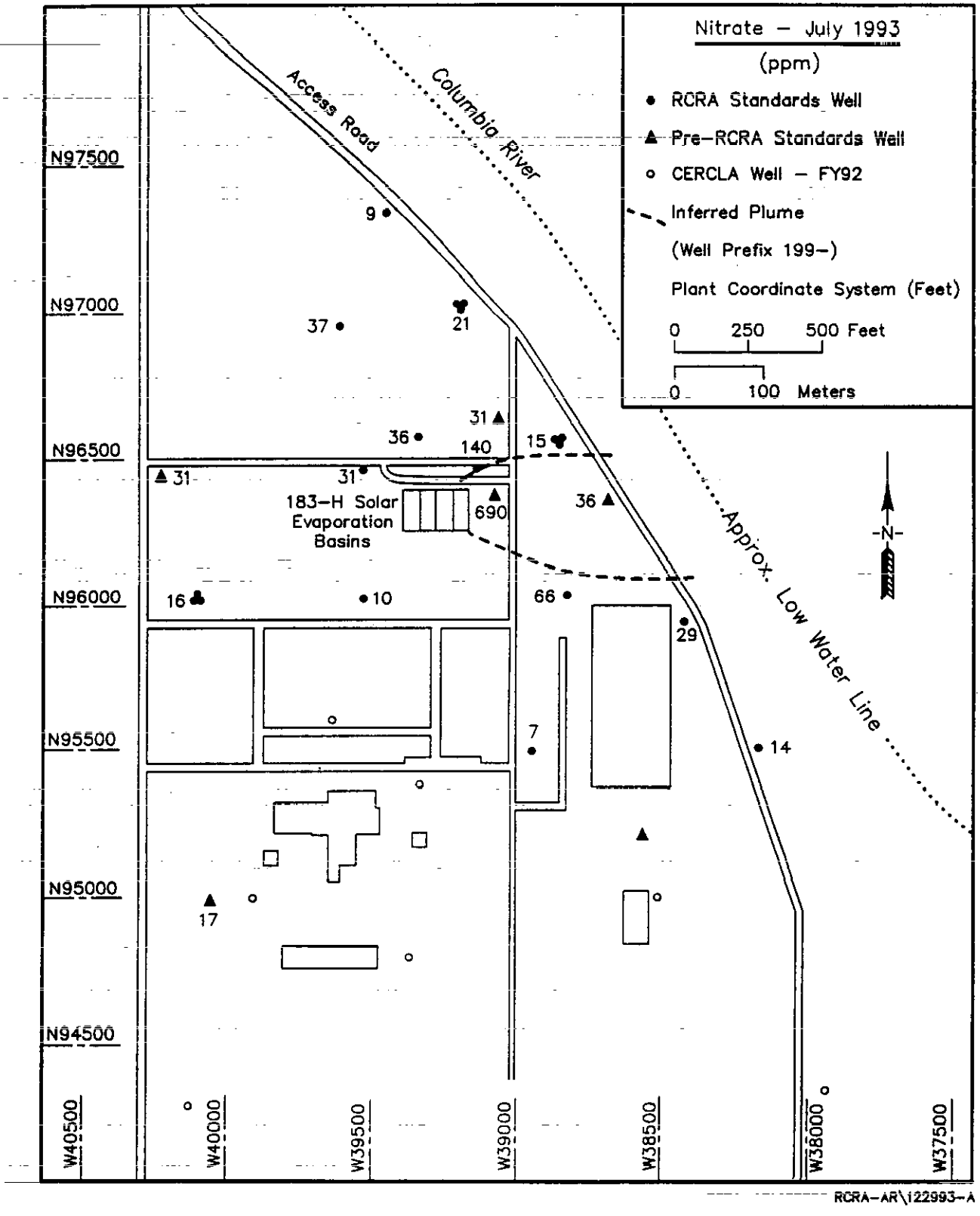


Figure 3.4-11. Sulfate Distribution Near the 183-H Basins, July 1993.

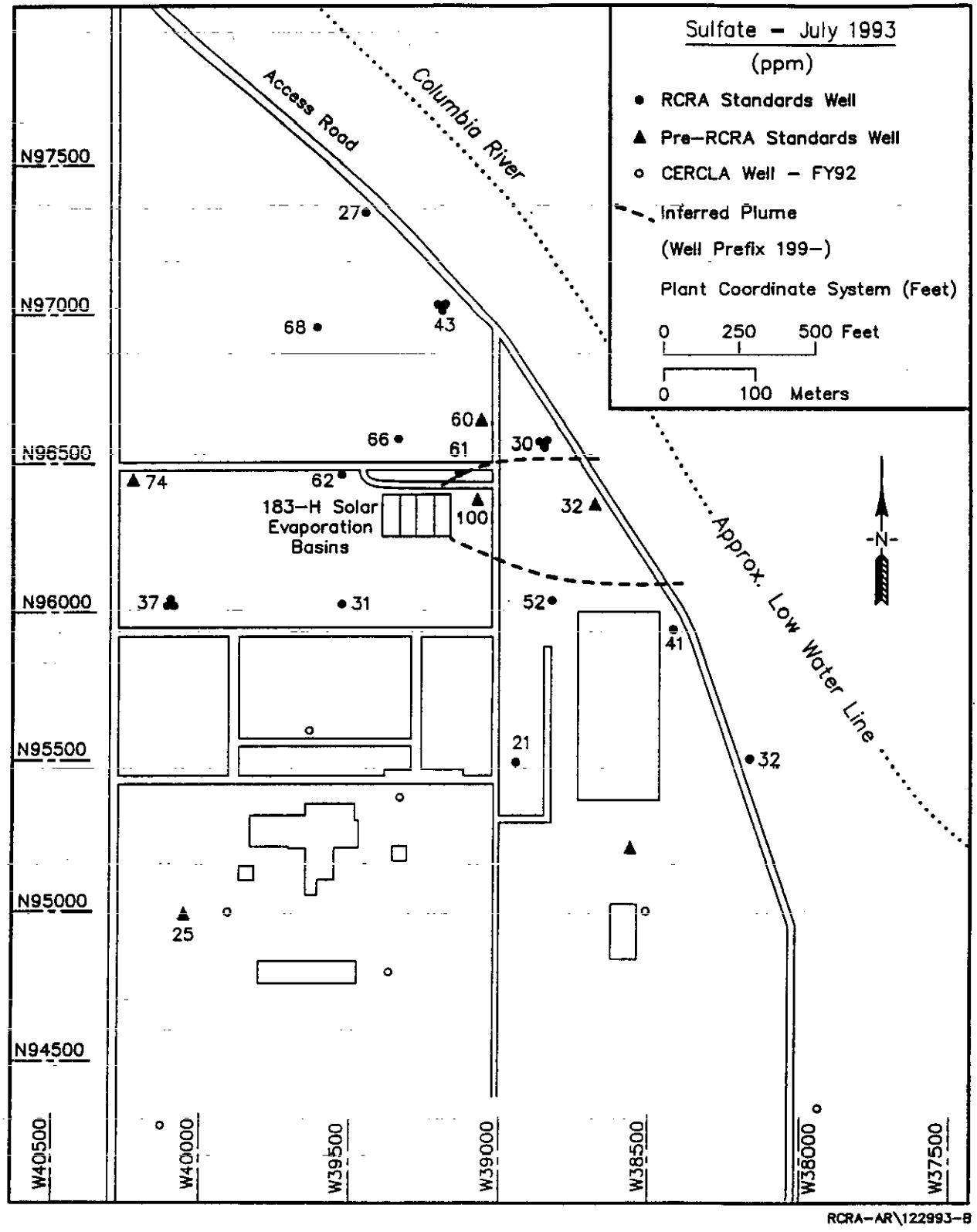


Figure 3.4-12. Sodium Distribution Near the 183-H Basins, July 1993.

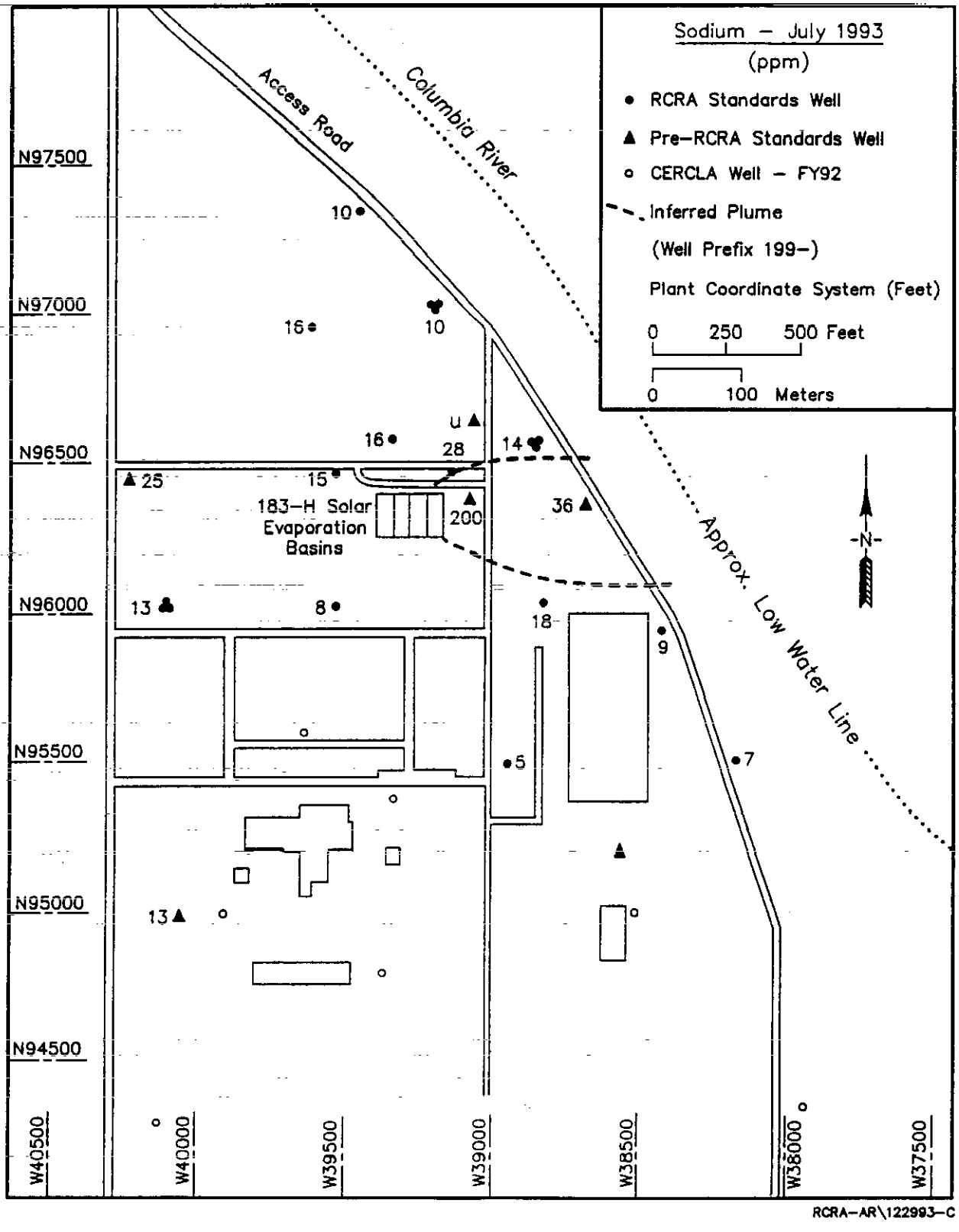


Figure 3.4-13. Gross Alpha Distribution Near the 183-H Basins, July 1993.

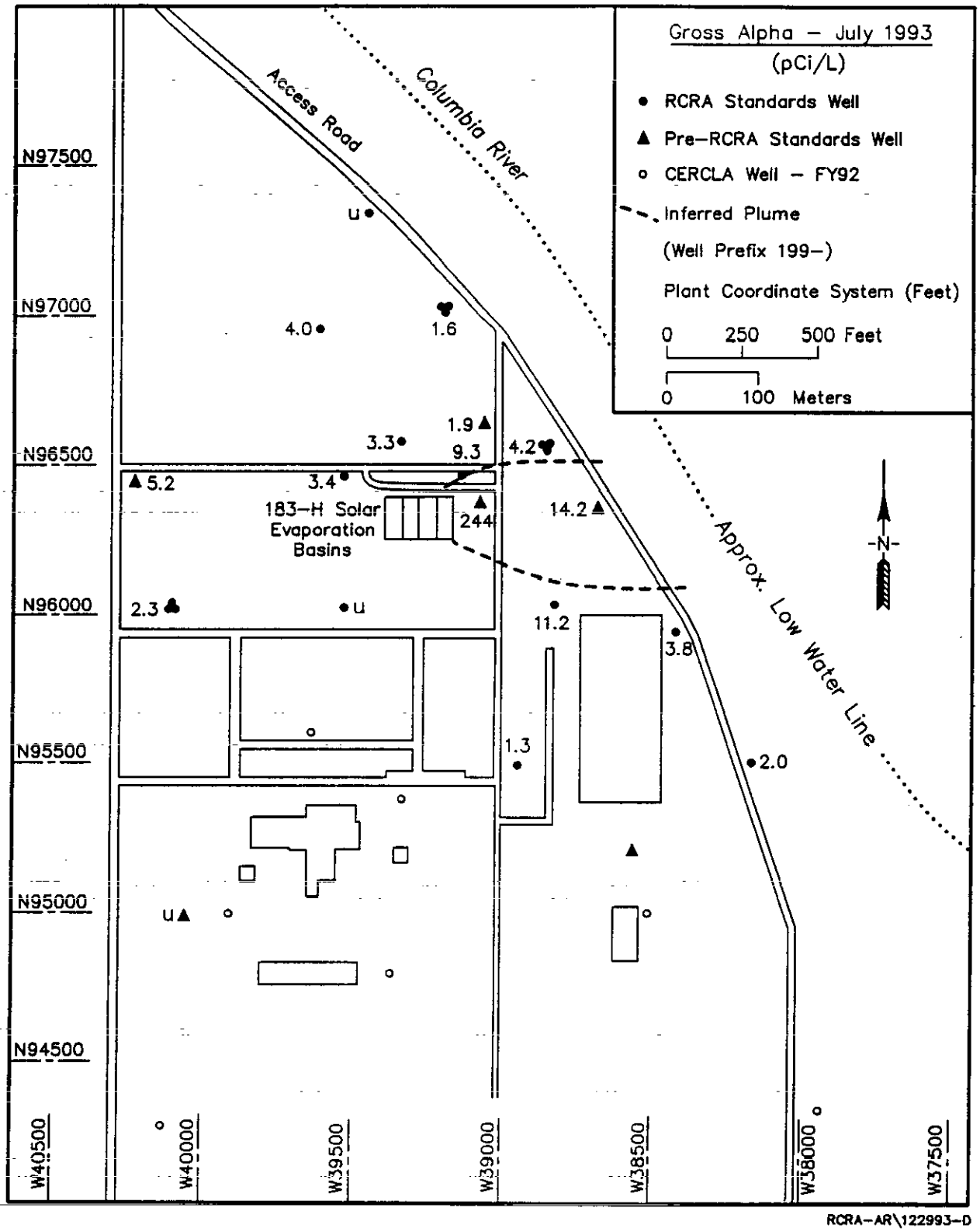


Figure 3.4-14. Gross Beta Distribution Near the 183-H Basins, July 1993.

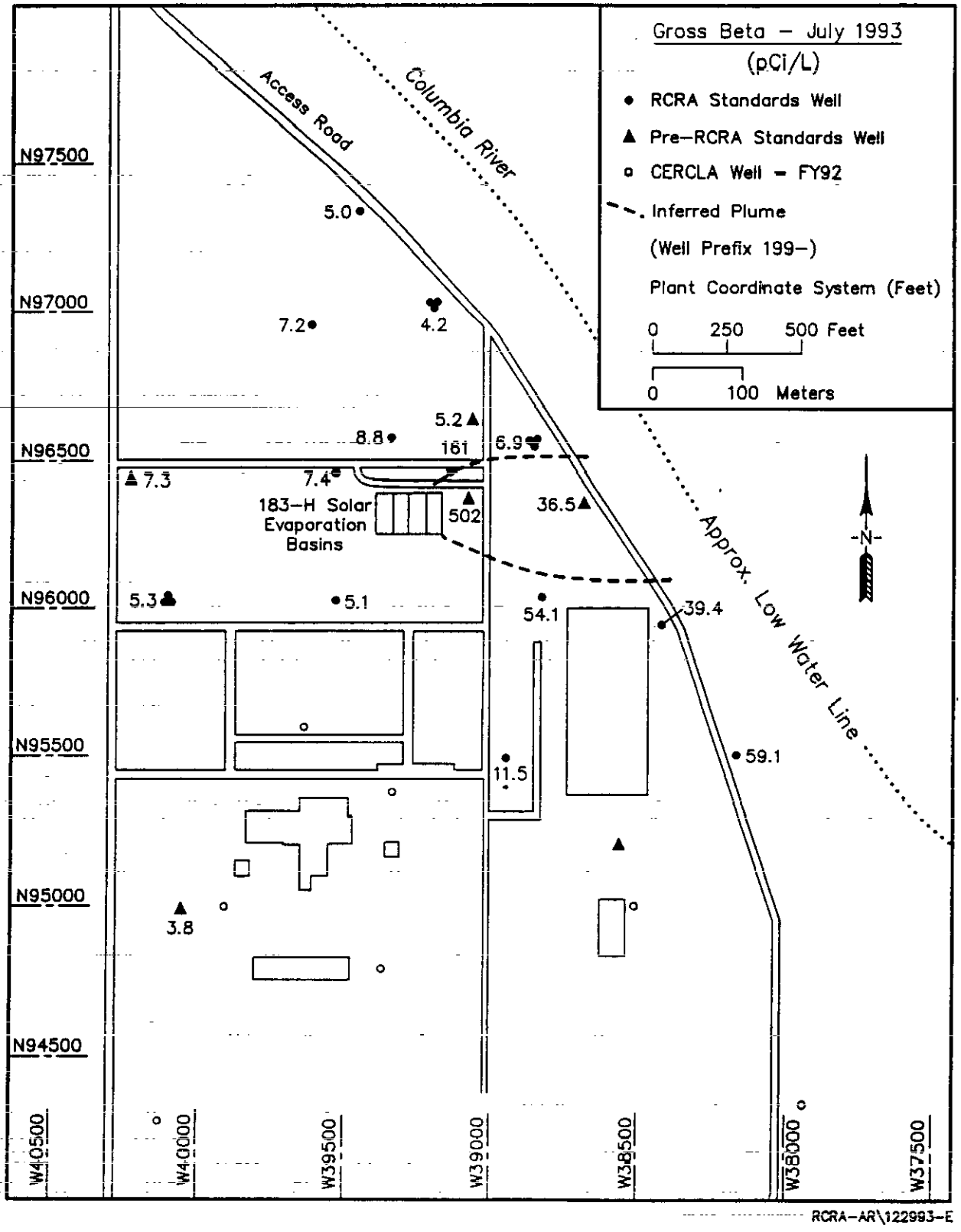


Figure 3.4-15. Chromium Distribution Near the 183-H Basins, July 1993.

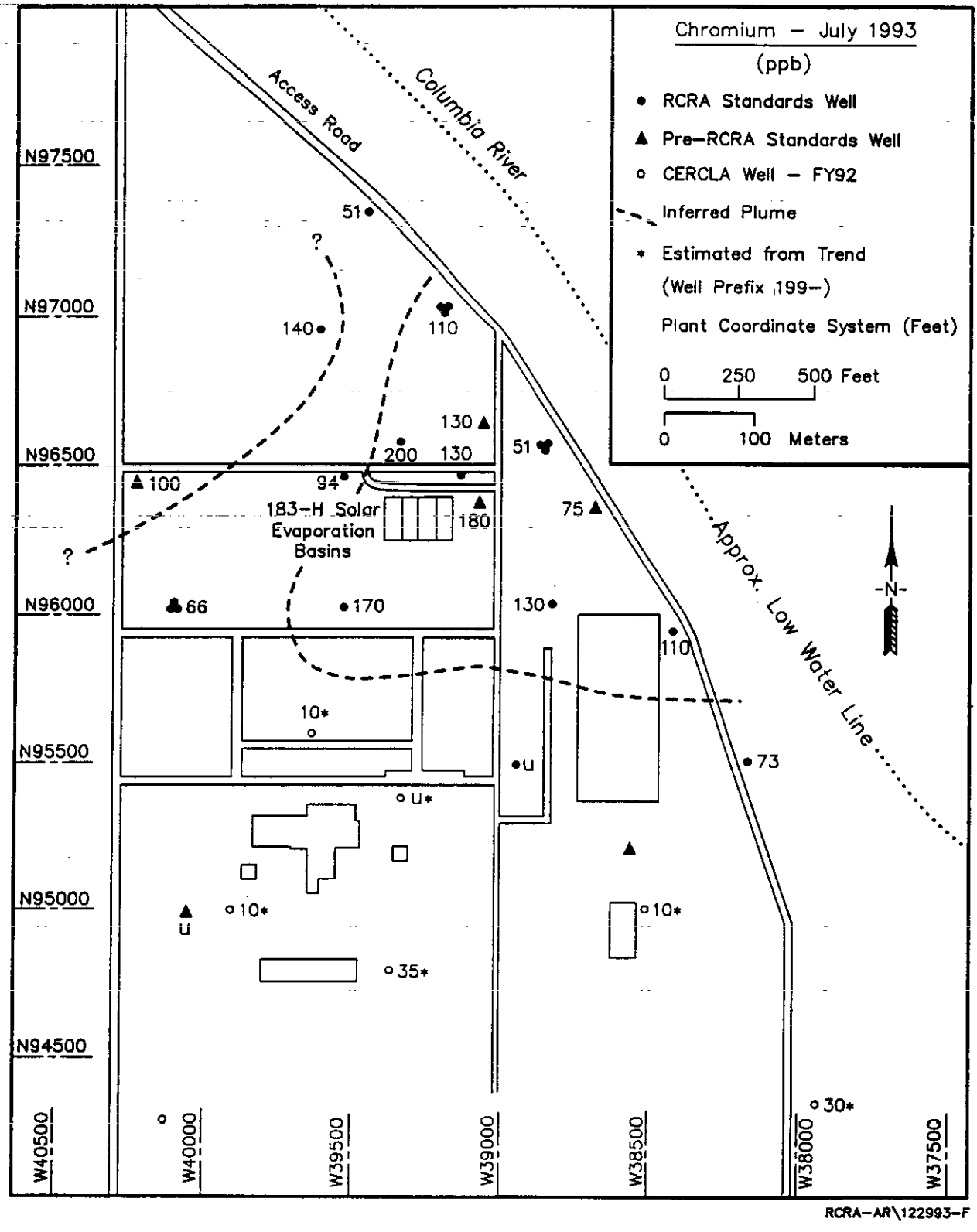
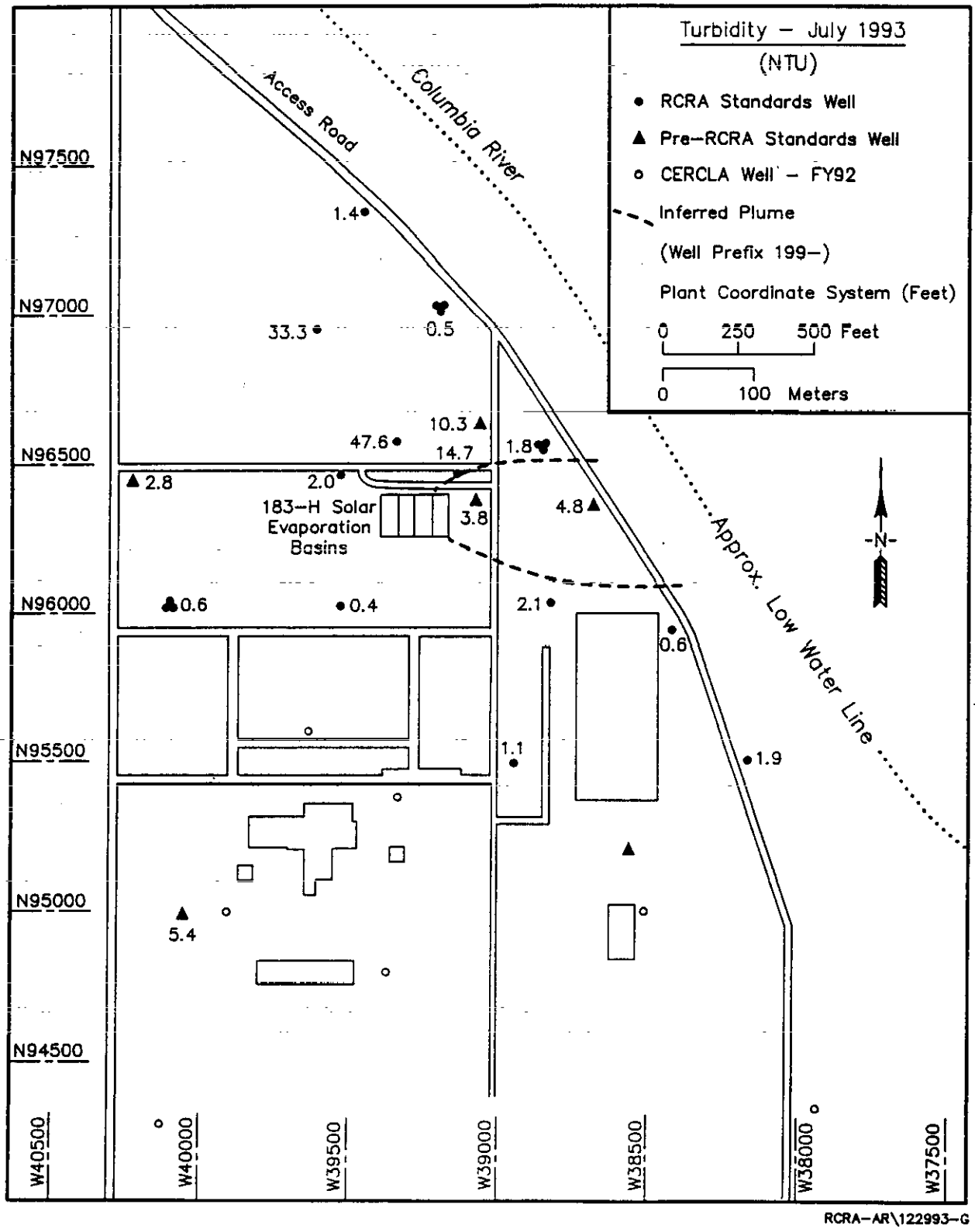


Figure 3.4-16. Turbidity Distribution Near the 183-H Basins, July 1993.



Waste indicator constituent concentrations are plotted for cluster well 199-H4-12, which is on the northern edge of the plume (Figures 3.4-17 through 3.4-22). None of the plots except chromium (see Figure 3.4-20) suggest downward migration of constituents to the mid-depth level in the Ringold Formation (-12C). Even near the Hanford/Ringold contact, the data from the uppermost well (-12A) in the Hanford sediments generally show higher concentrations than in the well immediately below the contact (-12B).

The chromium concentrations in cluster well 199-H4-12 are anomalous (see Figure 3.4-20). While the 199-H4-12A and 199-H4-12B wells show a historical trend that is representative of the 183-H plume, well 199-H4-12C is anomalous and probably not representative of aquifer conditions for several reasons. First, no other 183-H waste indicators are similarly elevated in this well. Second, field screening samples bailed from the piezometer tubes in nearby mid-depth well 199-H4-15C do not show elevated chromium levels. The background level for chromium at this depth in the aquifer is expected to be much lower and in the range observed in mid-depth well 199-H3-2C (Figure 3.4-23). The high chromium observed in well 199-H4-12C may be associated with some artifact of well construction, such as corrosion associated with stainless steel well screens (Hewitt 1994).

3.4.6 Groundwater Flow

Groundwater flow direction may be inferred from water table contour maps, from the shape of contaminant or other plumes, and by direct measurement in wells. The rate of flow can be estimated from water table gradients, using the Darcy flow relationship; from the migration rate of tracers between wells; and by direct measurement in wells. All of these methods have been used in the 100-H Area to describe groundwater flow.

3.4.6.1 Groundwater Flow Direction. Water table contours for August 9, 1993 are shown in Figure 3.4-24. The contours indicate that the potential for horizontal flow through the 100-H Area is generally to the northeast and nearly perpendicular to the river channel, with a slight deflection of the flow lines towards the downriver direction. This downriver component is revealed by water levels in wells located near the shoreline, where levels decrease in a downstream direction. The August contours reflect average water table characteristics for the year. A river hydrograph for the 100-H Area is included as Figure 3.4-25 and shows the seasonal variability to be expected in the water table near the shoreline.

Daily, weekly, and seasonal river level changes create short-term variability in flow patterns. High river levels reverse the hydraulic gradient near the river because of the elevation difference between river level and the water table. The normal flow of groundwater towards the river is retarded and effectively dammed by high river levels. River water moves into the river bank to a greater or lesser degree, depending on the height and duration of the river level. The influx of river water probably overlies groundwater rather than completely mixing with groundwater. Direct field evidence for this is being sought as part of groundwater/river interaction

Figure 3.4-17. Nitrate in Wells 199-H4-12A, 199-H4-12B, and 199-H4-12C.

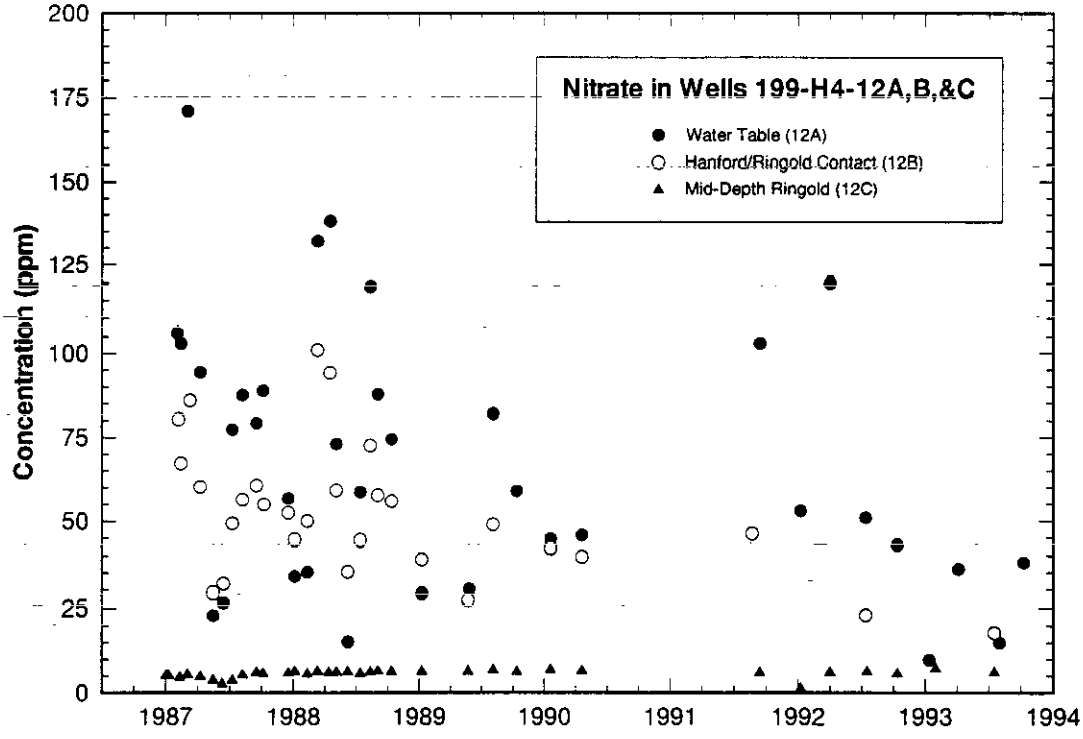


Figure 3.4-18. Sulfate in Wells 199-H4-12A, 199-H4-12B, and 199-H4-12C.

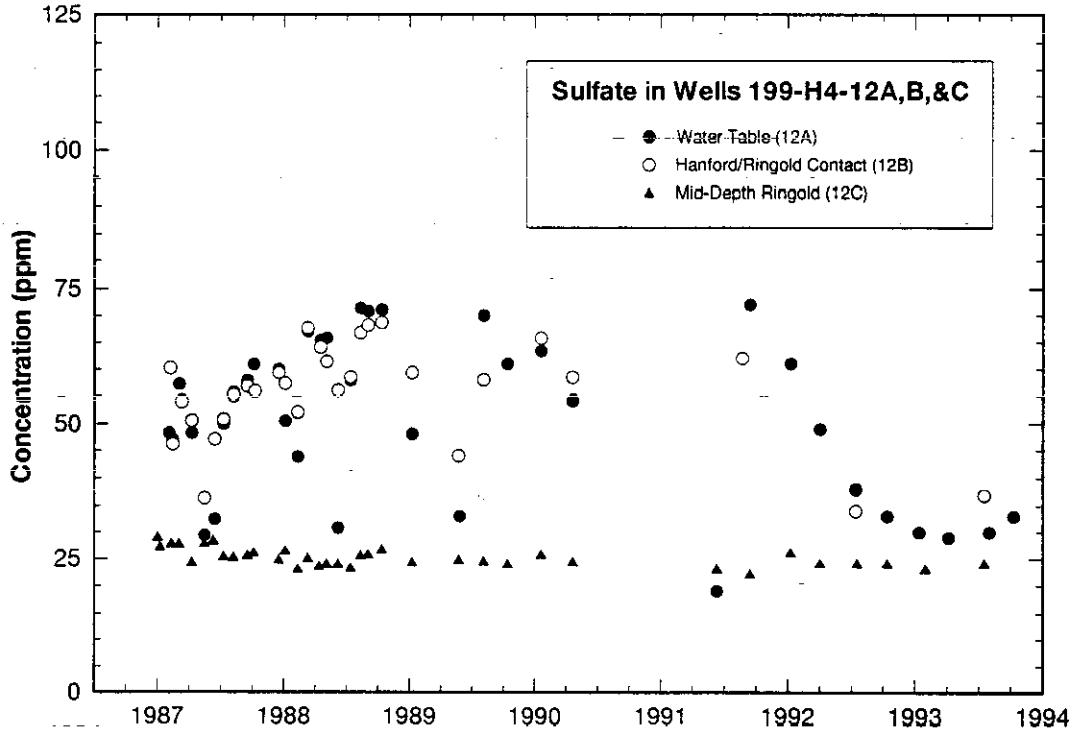


Figure 3.4-19. Sodium in Wells 199-H4-12A, 199-H4-12B, and 199-H4-12C.

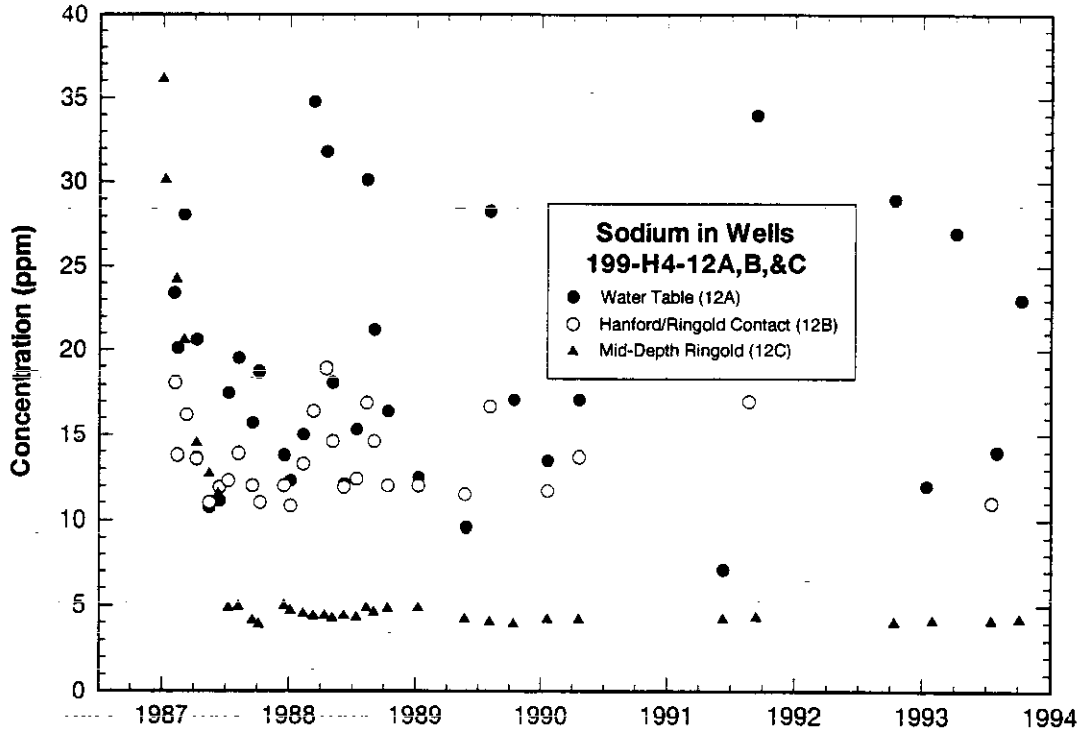


Figure 3.4-20. Chromium in Wells 199-H4-12A, 199-H4-12B, and 199-H4-12C.

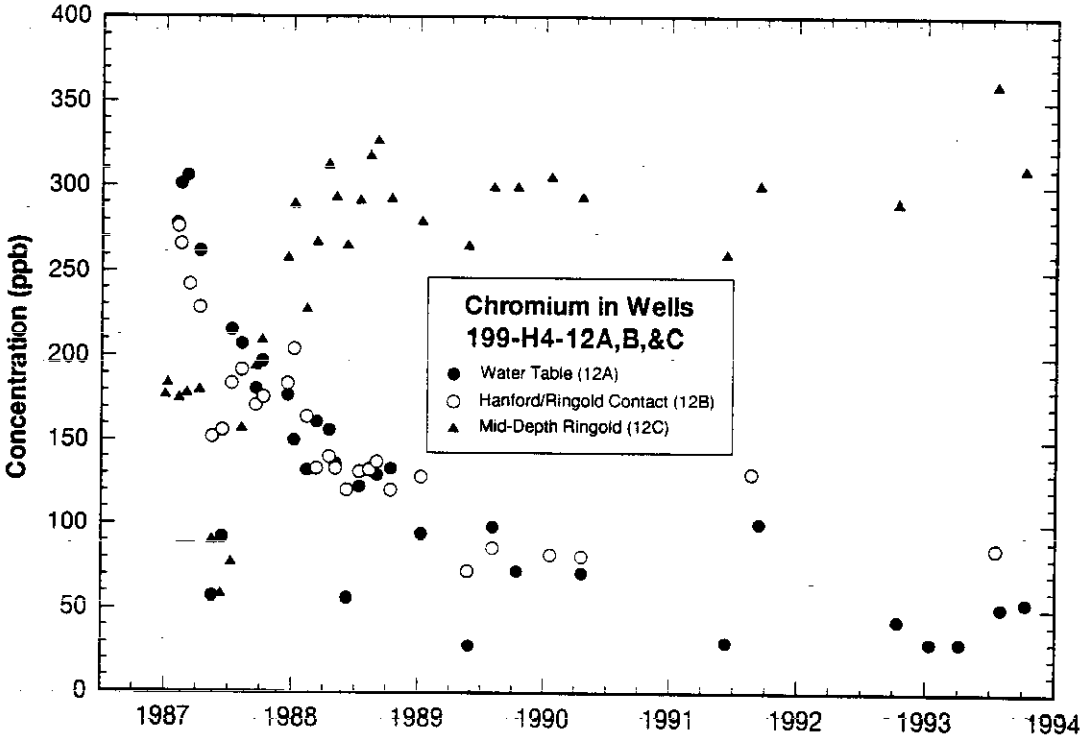


Figure 3.4-21. Gross Alpha in Wells 199-H4-12A, 199-H4-12B, and 199-H4-12C.

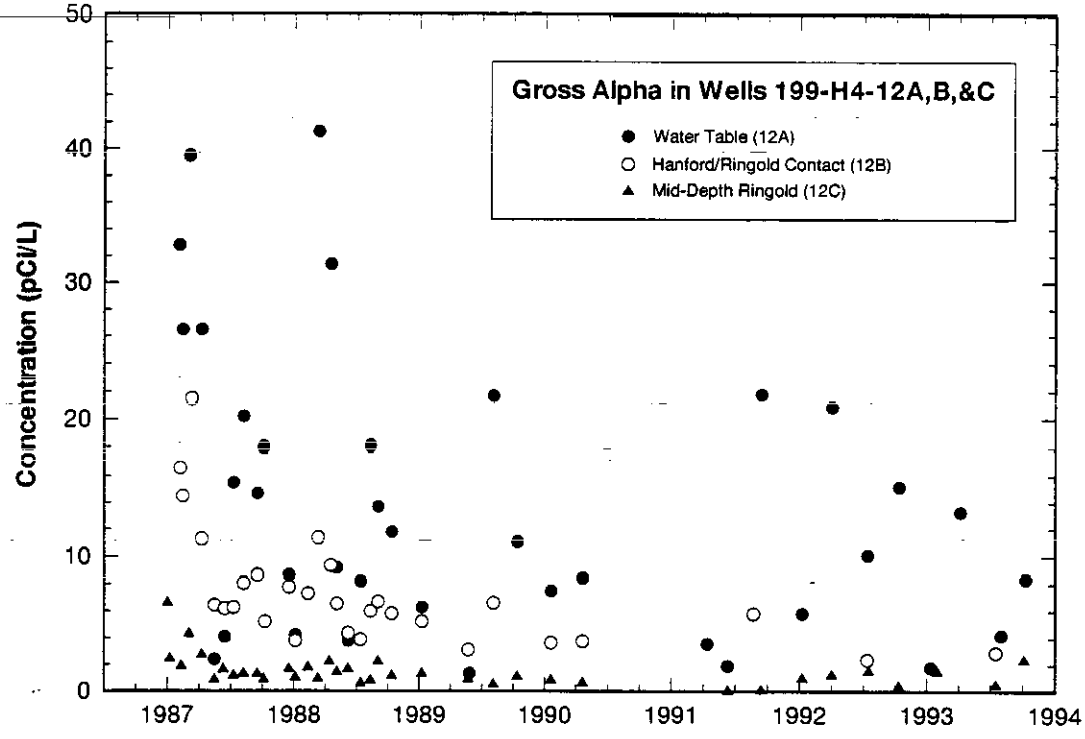
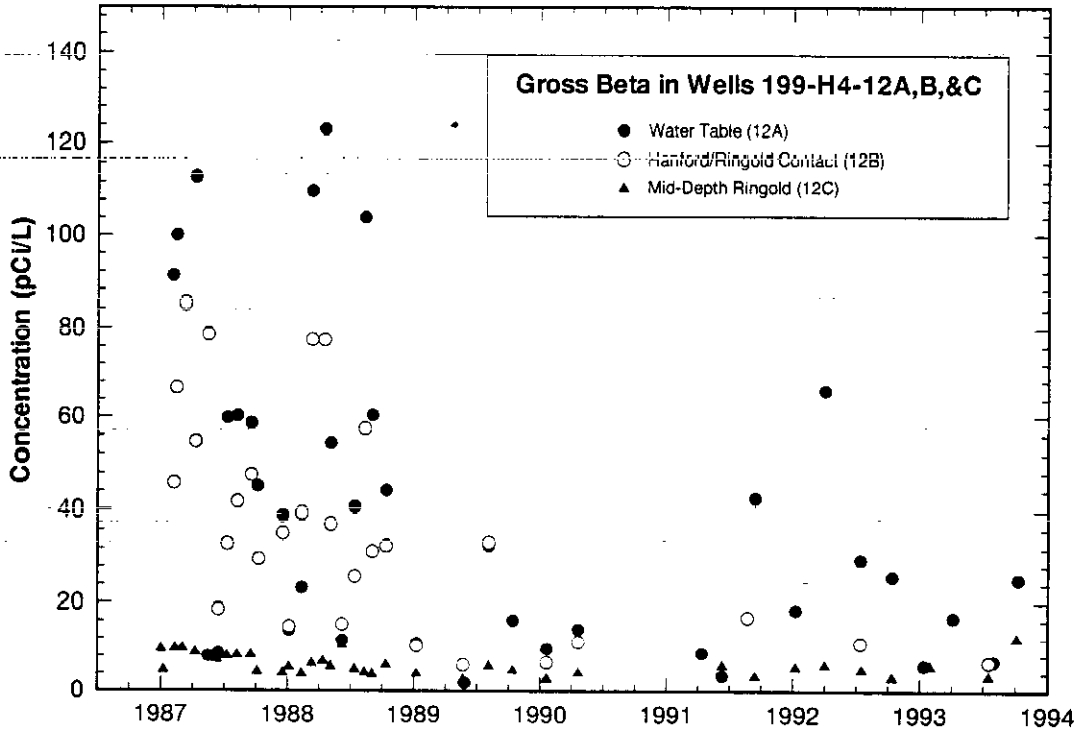


Figure 3.4-22. Gross Beta in Wells 199-H4-12A, 199-H4-12B, and 199-H4-12C.



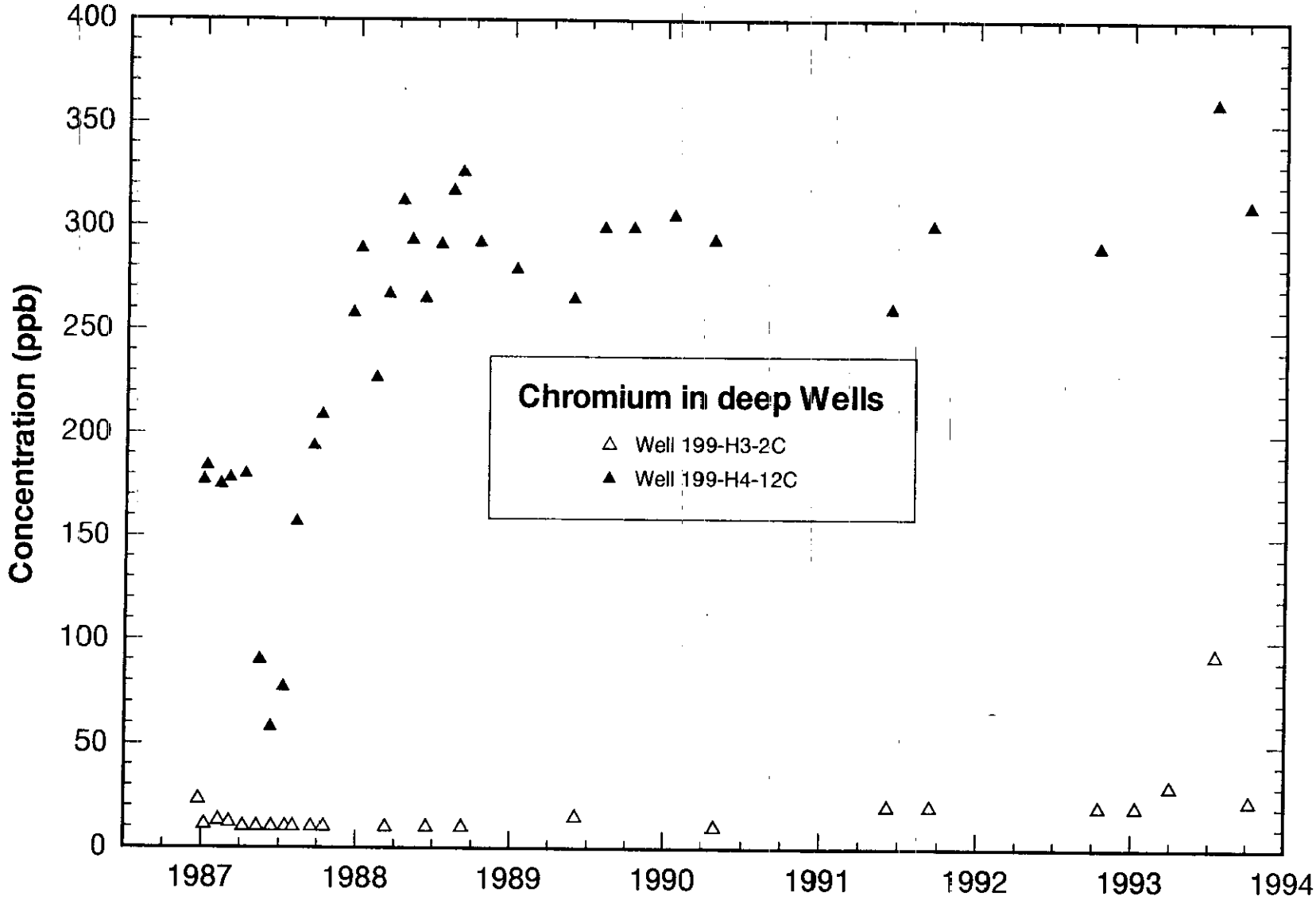


Figure 3.4-23. Chromium in Wells 199-H3-2C and 199-H4-12C.

Figure 3.4-24. 100-H Area Water Table Map for August 9, 1993.

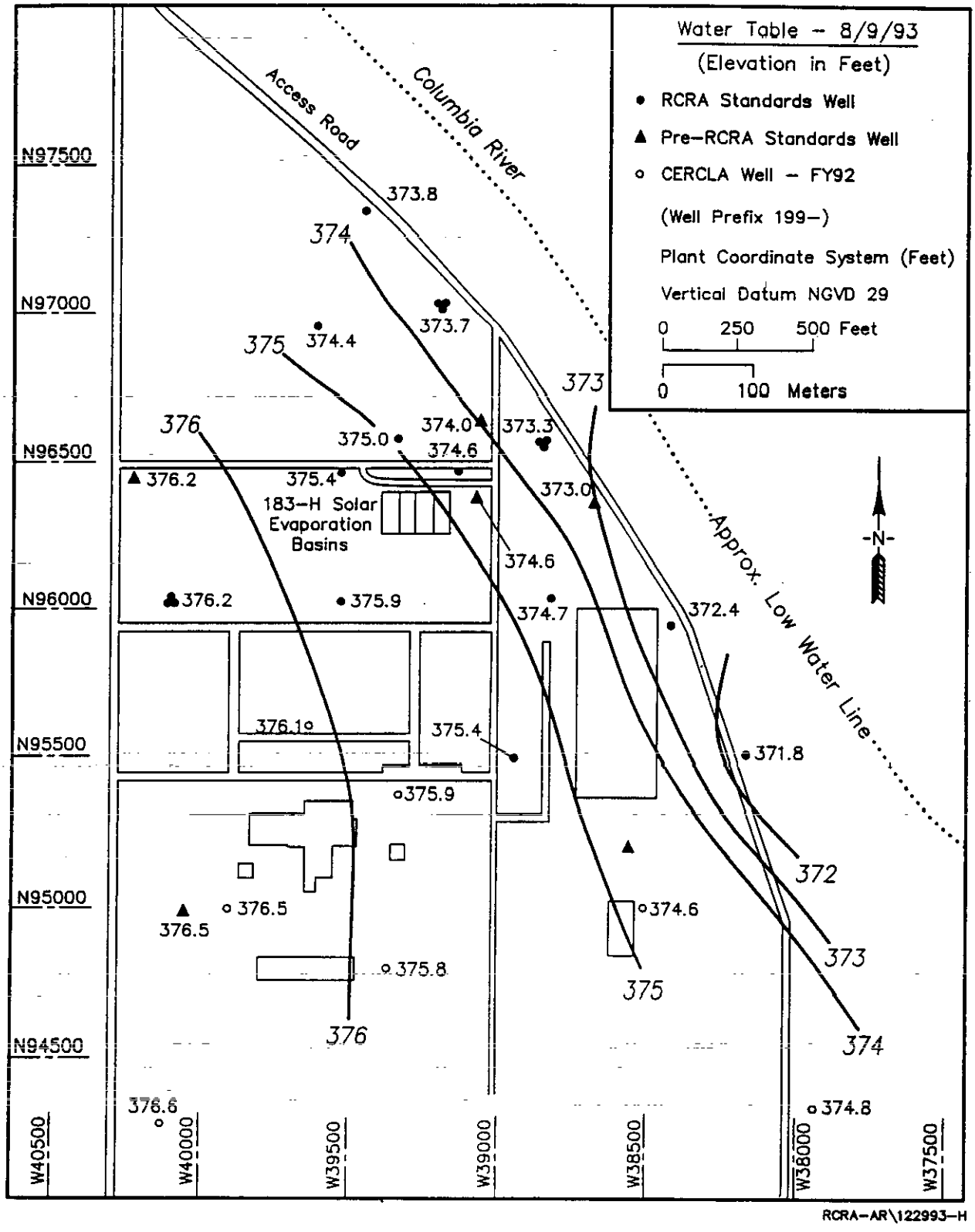
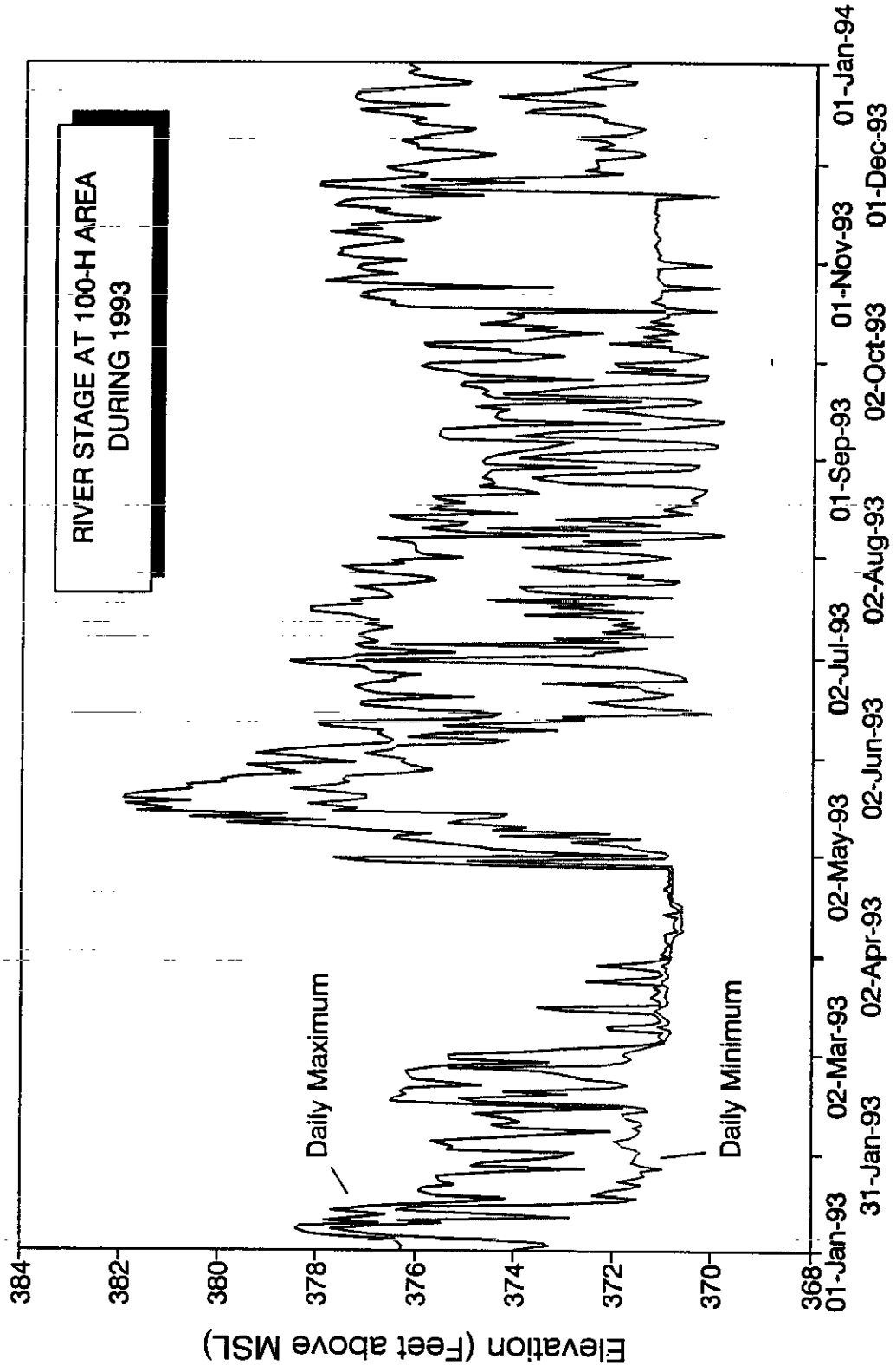


Figure 3.4-25. Columbia River Stage at 100-H Area During 1993.



investigations being conducted under the environmental restoration program (DOE-RL 1993a, Subtask 1A, "Characterization of 100 Area Contaminated Groundwater Inputs"). When the river level falls, the river water stored in the bank flows back towards the river, and groundwater resumes its flow towards the river under a more typical gradient.

The potential for vertical flow within the uppermost unconfined aquifer system is generally upward, although the direction can be reversed at the shallowest levels, in response to seasonal oscillations in the water table that are induced by river levels. At mid-depths in the unconfined aquifer, the potential for flow is upward, as indicated by data from well 199-H4-15CR. Vertical flow from the confined aquifers near the base of the Ringold Formation and upper Columbia River basalt units is upward. Evidence for this comes from flowing conditions at wells 199-H4-2 and 199-H4-15CP, both of which are completed in the uppermost basalt aquifer.

3.4.6.2 Rate of Flow. No new information on the plume's rate of movement has been developed during 1993. The rate of migration of waste constituents has been previously estimated using the following methods: (1) numerical flow models, (2) the Darcy equation for flow through porous media, (3) by analyzing time delays in the downgradient migration of waste indicator "pulses," and (4) by directly measuring speed and direction using an instrument lowered into a well.

Computer modeling based on an initial, limited water level data set indicated an average velocity of 0.31 m/d (1.0 ft/d) (Liikala et al. 1988). An estimate based on the migration of a single nitrate pulse suggested a value of 0.6 m/d (2 ft/d) (Hall 1989b). Darcy equation flow velocities calculated using observed water table gradients can easily accommodate values between 0.3 and 6 m/d (1 and 20 ft/d), depending on the hydraulic conductivity and effective porosity assumed in the equation (Peterson 1991). Analysis of the migration rate of nitrate pulses in two pairs of wells downgradient from 183-H Basins over a 3-year interval suggested rates of 2.56 to 4.82 m/d (8.4 to 15.8 ft/d) (Peterson 1992). Nitrate travels at essentially the same rate as groundwater flow, because that constituent is not sorbed onto sediments or reduced appreciably by chemical reactions or other attenuating phenomena. In October 1992, a downhole instrument was used to measure groundwater flow velocity directly in well 199-H4-48. The results indicated a flow velocity of 1 m/d (3 ft/d) towards the northeast, which is consistent with other evidence for flow rate and direction in the vicinity of this well.

3.4.6.3 Evaluation of Monitoring Network. Monitoring well coverage around the 183-H Basins is deemed adequate to detect and delineate a groundwater contamination plume emanating from the basins. The network meets the minimal requirements of 40 CFR 265, Paragraph 265.91, for a groundwater monitoring system. The number and placement of wells has been described in a groundwater monitoring plan (PNL 1986) that has been reviewed by regulatory agencies. The initial sampling and analysis program for these wells is described in that plan, and updates to the sampling and analysis program are presented in quarterly and annual RCRA reports (see Chapter 1.0).

3.4.7 References

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Resource Conservation and Recovery Act of 1976, 42 USC 6901 et seq.

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4.0 200 AREAS

4.1 HYDROGEOLOGIC SETTING OF THE 200 AREAS

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The 200 Areas encompasses a large region central to the Hanford Site. Within the 200 Areas are the 200 West Area and the 200 East Area where nuclear fuel processing plants and various waste management facilities exist.

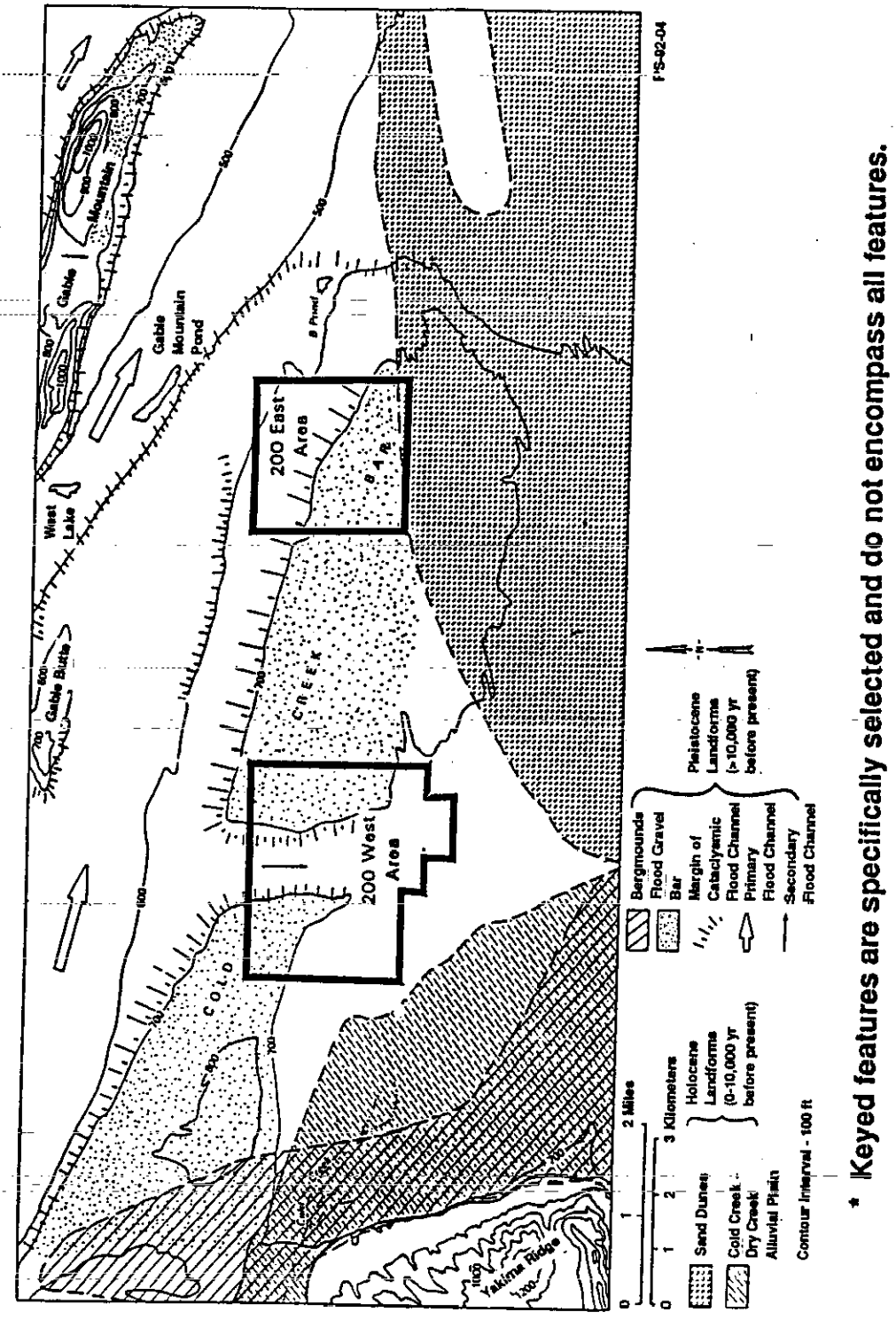
Much of the hydrogeologic data and information presented in this section are from the *200 West Groundwater Aggregate Area Management Study Report* (DOE-RL 1993b) and the *200 East Groundwater Aggregate Area Management Study Report* (DOE-RL 1993a). These documents were drafted to support the recently completed 200 Aggregate Area Management Study (200 AAMS). A primary objective of the 200 AAMS was to collate and evaluate all available 200 Areas environmental data. Hydrogeologic data collected and evaluated in the 200 AAMS reports have resulted in the most current understanding of the 200 Areas hydrogeology. Other more recent reports and references have been used to supplement information extracted from the 200 AAMS reports. These additional sources are referenced where appropriate.

4.1.1 Physiography and Topography of the 200 Areas

The 200 Areas are situated on a broad plateau commonly referred to as the 200 Areas Plateau. The 200 Areas Plateau is located in a synclinal flexure in the Columbia River Basalt known as the Cold Creek syncline. Land surface elevation for the 200 Areas Plateau ranges from approximately 200 to 230 m (656 to 755 ft) above mean sea level. The plateau decreases in elevation to the north, northwest, and east with elevation changes between 15 to 30 m (49 to 98 ft) near the plateau escarpments to the north.

The 200 Areas Plateau is formed primarily by the Cold Creek bar, an east-west trending depositional feature that developed as a result of large-scale flood events associated with periodic catastrophic draining of ancient Lake Missoula during the Pleistocene Epoch. The northern extent of the 200 Areas Plateau is defined by the Gable Mountain-Gable Butte anticline complex and two major northwest-southeast trending flood channels. In addition to these main channels, a north-south trending secondary flood channel transects the 200 West Area. The geomorphology to the south the 200 Areas is dominated by the Cold Creek-Dry Creek alluvial plain and Holocene sand dune and sheet sand deposits. Holocene sand dunes and sheet sands also dominate to the east of the 200 Areas, while to the west the Cold Creek-Dry Creek alluvial plain and bergmounds deposited during the Lake Missoula catastrophic flood events dominate the landscape. The geographic relationship of these landforms in and surrounding the 200 Areas is illustrated in Figure 4.1-1.

Figure 4.1-1. Geographic Features Surrounding the 200 Areas (modified from Last et al. 1989).



4.1.2 Geology and Stratigraphy of the 200 West Area

Geologic and stratigraphic characteristics distinctive of the 200 West area are provided in this section. Significant stratigraphic characteristics including thickness variations, dip trends, and spatial relationships are also provided. Stratigraphic units of significance in the 200 West Area include: (1) Elephant Mountain Member of the Saddle Mountains Basalt; (2) Ringold Formation including units A, E, lower mud sequence, and upper Ringold; (3) Plio-Pleistocene/"early" Palouse soil interval; and (4) Hanford formation. Detailed geologic cross sections for the 200 West Area are provided in Figures 4.1-2 through 4.1-5.

4.1.2.1 Elephant Mountain Member. The Elephant Mountain Member of the Saddle Mountains Basalt is continuous throughout the 200 West Area. This basalt flow ranges from 160 to 182 m (525 to 597 ft) in depth below ground surface with a gentle structural dip to the south and southwest. Average thickness of the Elephant Mountain Member beneath the 200 West Area ranges from 18 to 36 m (59 to 118 ft).

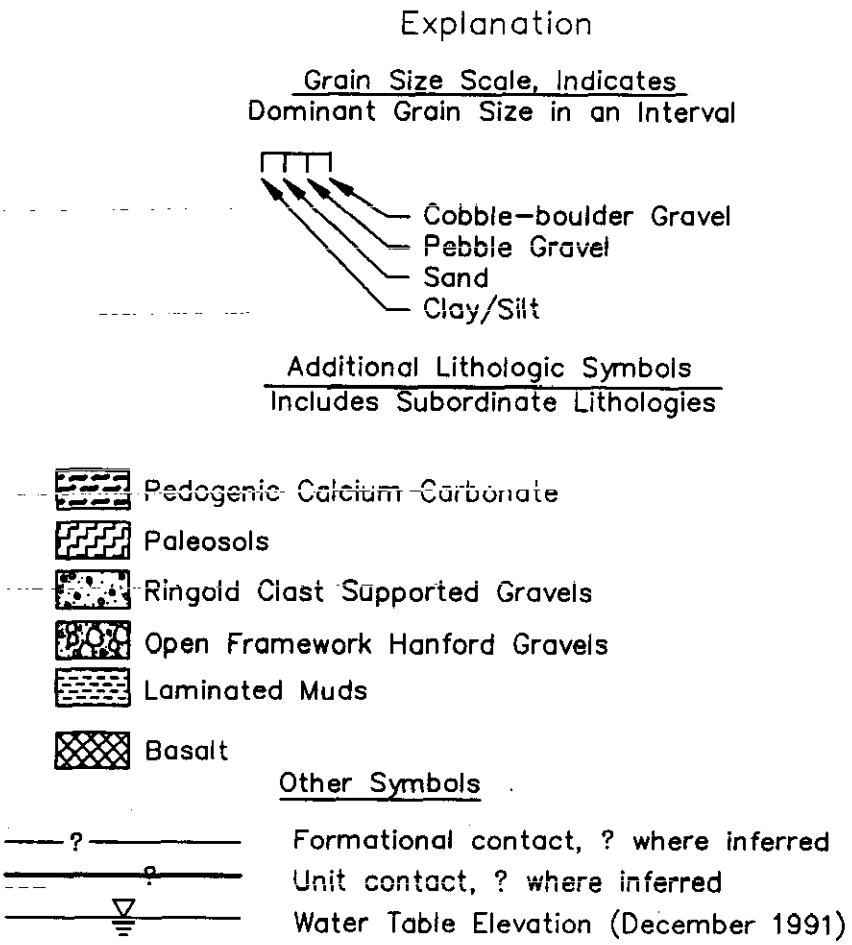
Studies conducted to date do not indicate the presence of faults or significant fracture systems in the Elephant Mountain Member beneath the 200 West Area. Generally basalts are composed of various interflow structures that affect their geologic and hydrologic characteristics. Data on these features for the Elephant Mountain Member specific to the 200 West Area are not available.

4.1.2.2 Ringold Formation. Beneath the 200 West Area the Ringold Formation is composed of fluvial gravel unit A, the lower mud sequence, fluvial gravel unit E, and the Upper Ringold unit. Fluvial gravel unit A directly overlies the Elephant Mountain Member. Fluvial gravel unit A is composed primarily of gravels with some intercalated sand and silt lenses in the western and southern portions of the 200 West Area. Thickness of the unit increases to a maximum of 30 m (98 ft) to the south. The unit thins to the north and pinches out just north of the 200 West fence line. This unit is continuous beneath the 200 West Area.

The fine-grained lacustrine deposits of the lower mud sequence are found overlying fluvial gravel unit A throughout most of the 200 West Area, excluding the northeast corner of the 200 West Area where it pinches out. The lower mud sequence exhibits an irregular structural surface and reaches a maximum thickness of 34 m (111 ft) in the west-central portion of the 200 West Area.

Overlying the lower mud sequence is fluvial gravel unit E. This unit is continuous throughout the 200 West Area and displays a wide variation in thickness and structural orientation. The thickness of unit E varies from 107 m (351 ft) in the north to less than 55 m (180 ft) in the southwest portion of the 200 West Area. Fluvial gravel unit E exhibits an irregular structural surface with several highs in the northern and southern portions of the 200 West Area and several lows in the central portion.

Figure 4.1-2. Legend for Geologic Cross Sections.



Unit Abbreviations

Hc – Upper Coarse Unit, Hanford formation
Hf – Lower Fine Unit, Hanford formation
EP – Early "Palouse" Soil
PP – Plio–Pleistocene Unit
UR – Upper Unit, Ringold Formation
E – Gravel Unit E, Ringold Formation
LM – Lower Mud Sequence, Ringold Formation
A – Gravel Unit A, Ringold Formation

Blank portions of cross section well logs represent sediments (dominantly sand) which do not fit into sediment categories depicted by symbols listed above.

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Figure 4.1-3. Location of 200 West Area Geologic Cross Sections.

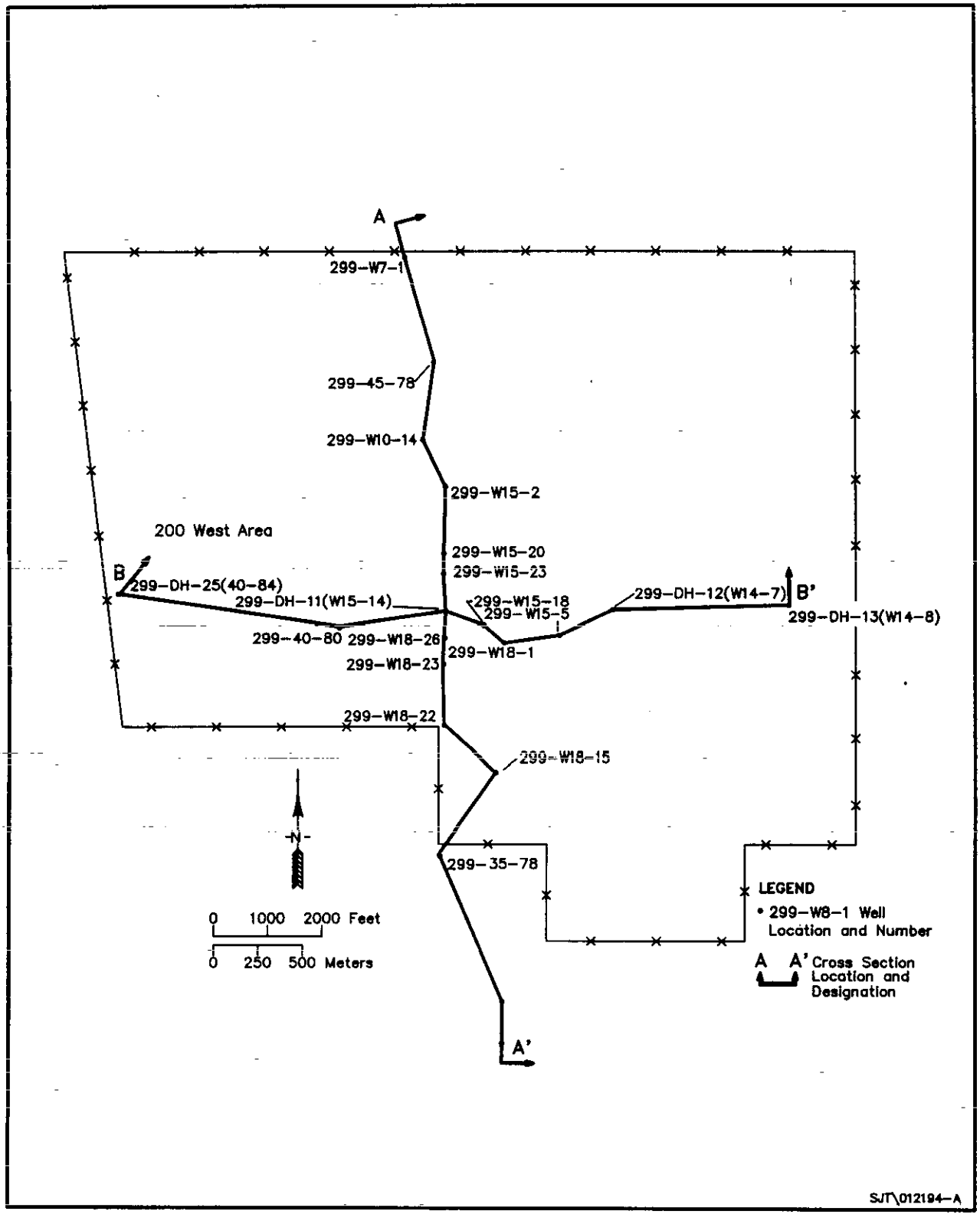

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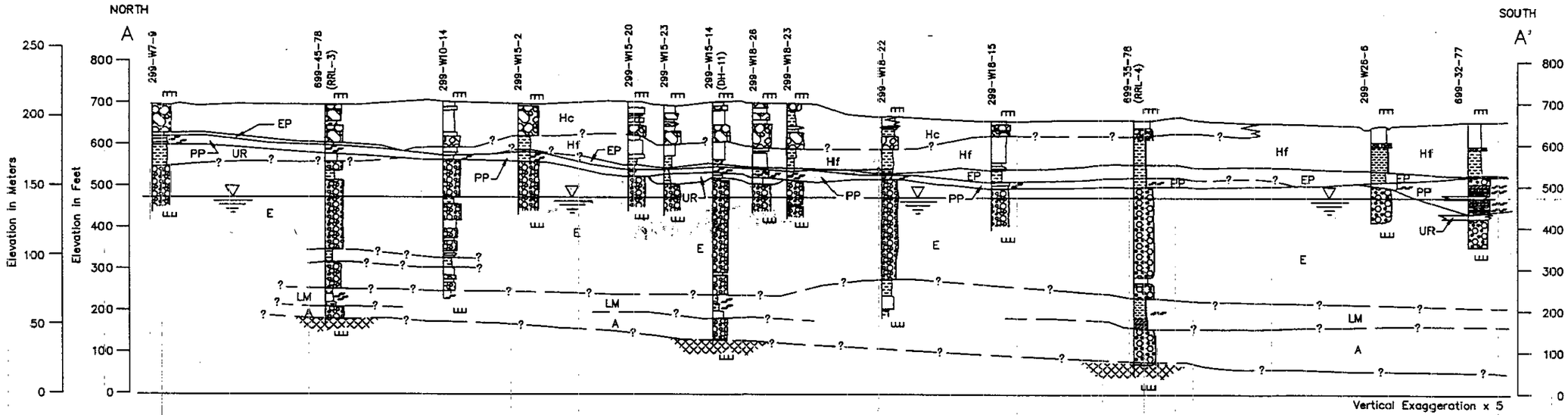
Figure 4.1-4. 200 West Area Geologic Cross Section A-A'.



NOTE

Refer to Figure 4.1-4 for cross section location and Figure 4.1-3 for legend. Figure based on Lindsey et al. 1991.

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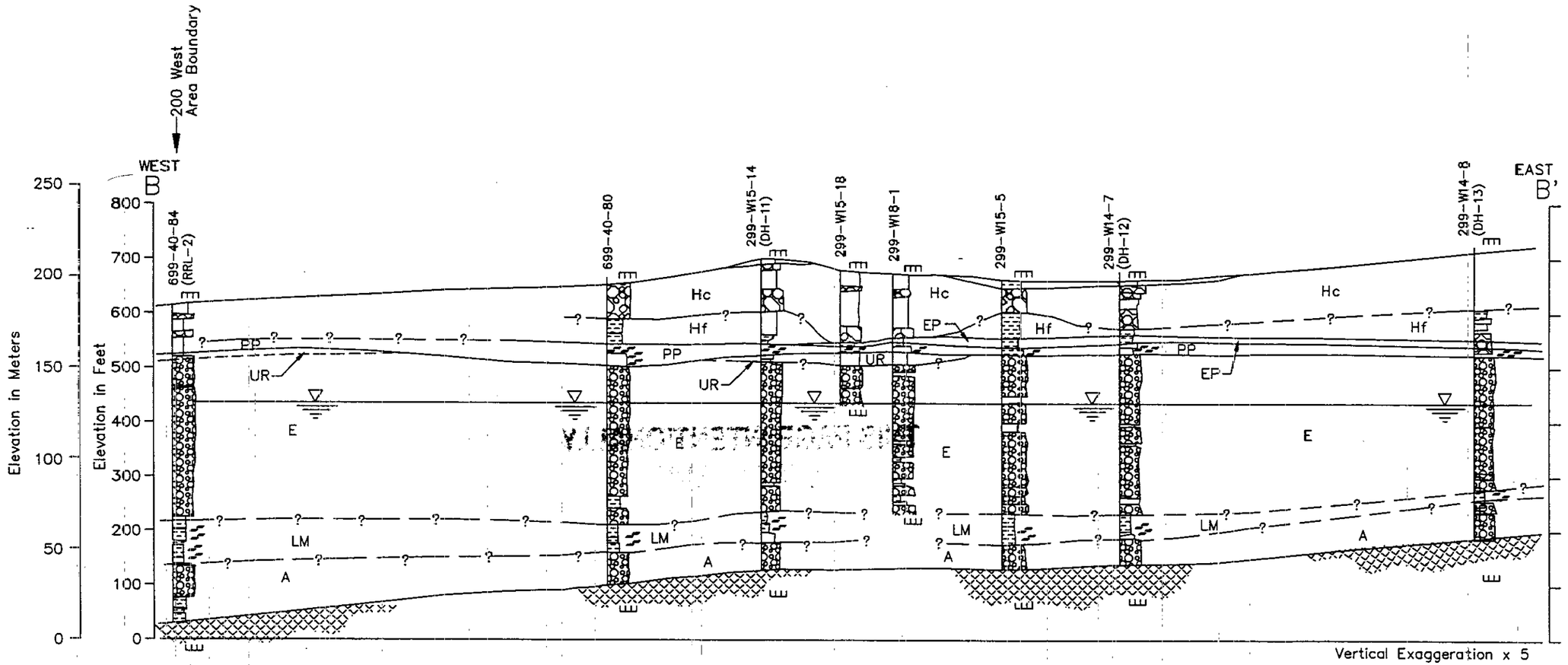
Figure 4.1-5. 200 West Area Geologic Cross Section B-B'.



Horizontal Scale in Feet
0 1000 2000
Horizontal Scale in Meters
0 200 400 600

NOTE
Refer to Figure 4.1-4 for cross section location and Figure 4.1-3 for legend. Figure based on Lindsey et al. 1991.

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The upper unit of the Ringold Formation is present only in the western, northern, and central portions of the 200 West Area. The structural surface generally dips to the south-southwest where the upper unit is present. The upper unit reaches a thickness of 14 m (46 ft) or more in the central and northwest portions of the 200 West Area.

4.1.2.3 Plio-Pleistocene/"Early" Palouse Soil Interval. The Plio-Pleistocene unit beneath the 200 West Area is composed primarily of the carbonate-rich paleosol facies. A high degree of variation in the texture and composition of this unit is common beneath the 200 West Area with carbonate-rich and carbonate-poor lithologies often intercalated. The Plio-Pleistocene unit pinches out near the northern, eastern, and southern boundaries of the 200 West Area. Thickness of the Plio-Pleistocene unit is irregular and varies significantly throughout the 200 West Area. The unit is thickest in the southeast, southwest, and north-central parts of the 200 West Area while it thins in the south-central and central portions. In general, the unit dips to the south and southwest. Undetected erosional windows may be present in the Plio-Pleistocene unit in areas where the unit is unusually thin. In addition, fracturing in the carbonate-rich zones may be a significant hydrologic feature of the Plio-Pleistocene unit.

The "early" Palouse soil is largely restricted to the vicinity of the 200 West Area. Identification of the "early" Palouse soil in the subsurface is difficult because of the textural and compositional similarities to the silt-dominated facies of the overlying Hanford formation. It is likely that the silt-dominated facies of the Hanford formation has been erroneously identified as the "early" Palouse soil in some portions of the 200 West Area (Rohay et al. 1993).

4.1.2.4 Hanford Formation. In the 200 West Area the Hanford formation has been subdivided into two units based on texture and clast grain size. These units are referred to as the lower fine-grained unit and the upper coarse-grained unit. Neither of these units are laterally continuous in the 200 West Area, and both typically exhibit a significant amount of textural heterogeneity. The aggregate thickness of these units ranges from 10 to 75 m (33 to 246 ft) and generally thickens from north to south.

The lower fine-grained unit is primarily composed of silt, silty sands, and sands. The silt and silty sands display successions or packets of fining upward sequences. These fining upward sequences are generally analogous to textural features characteristic of the silt-dominated facies of the Hanford formation. Interbedded with the silt and silty sand fining upward sequences are coarser sands and gravels. These coarser sand and gravel beds are analogous to the textural features characteristic of the sand-dominated facies of the Hanford formation. Although highly variable, it appears that the lower fine-grained unit becomes finer grained to the south with a higher sand and gravel content to the north. The lower fine-grained unit is thick but locally discontinuous. This unit pinches out in the northern portion of the 200 West Area but thickens to approximately 32 m (105 ft) in the southern portion of the 200 West Area. In addition, the lower fine-grained unit has apparently been removed from an erosional zone trending north-south through the center of the 200 West Area. The lower fine-grained unit is probably correlative with the sandy sequence of the Hanford formation found in the 200 East Area as discussed in Section 4.1.3. Clastic dikes have been found crosscutting the

lower fine-grained unit in the 200 West Area. The clastic dikes appear to be randomly distributed in the unit and oriented near vertical. Typical fill material found in these dikes includes fine sand and silt.

The upper coarse-grained unit of the Hanford formation consists of intercalated gravel, sand, and some silt. The upper coarse-grained unit is generally analogous to the gravel-dominated facies of the Hanford formation. However, in some locations the upper coarse-grained unit is composed primarily of coarse-grained sand more analogous of the sand-dominated facies of the Hanford formation. Similar to the lower fine-grained unit, the upper coarse-grained unit is very heterogeneous with respect to texture and clast size. Fining upward sequences are also observed in this unit, typically displaying a gradation from coarse gravels to sands and sometimes even silt. The thickness of the upper coarse-grained unit approaches a maximum of 45 m (148 ft) but is laterally discontinuous in the northern, east-central, and eastern portions of the 200 West Area. The upper coarse-grained unit also fills the north-south trending erosional zone found in the lower fine-grained unit. Although clastic dikes are most commonly found in the lower fine-grained unit, they can also be found crosscutting the upper coarse-grained unit in a few localities.

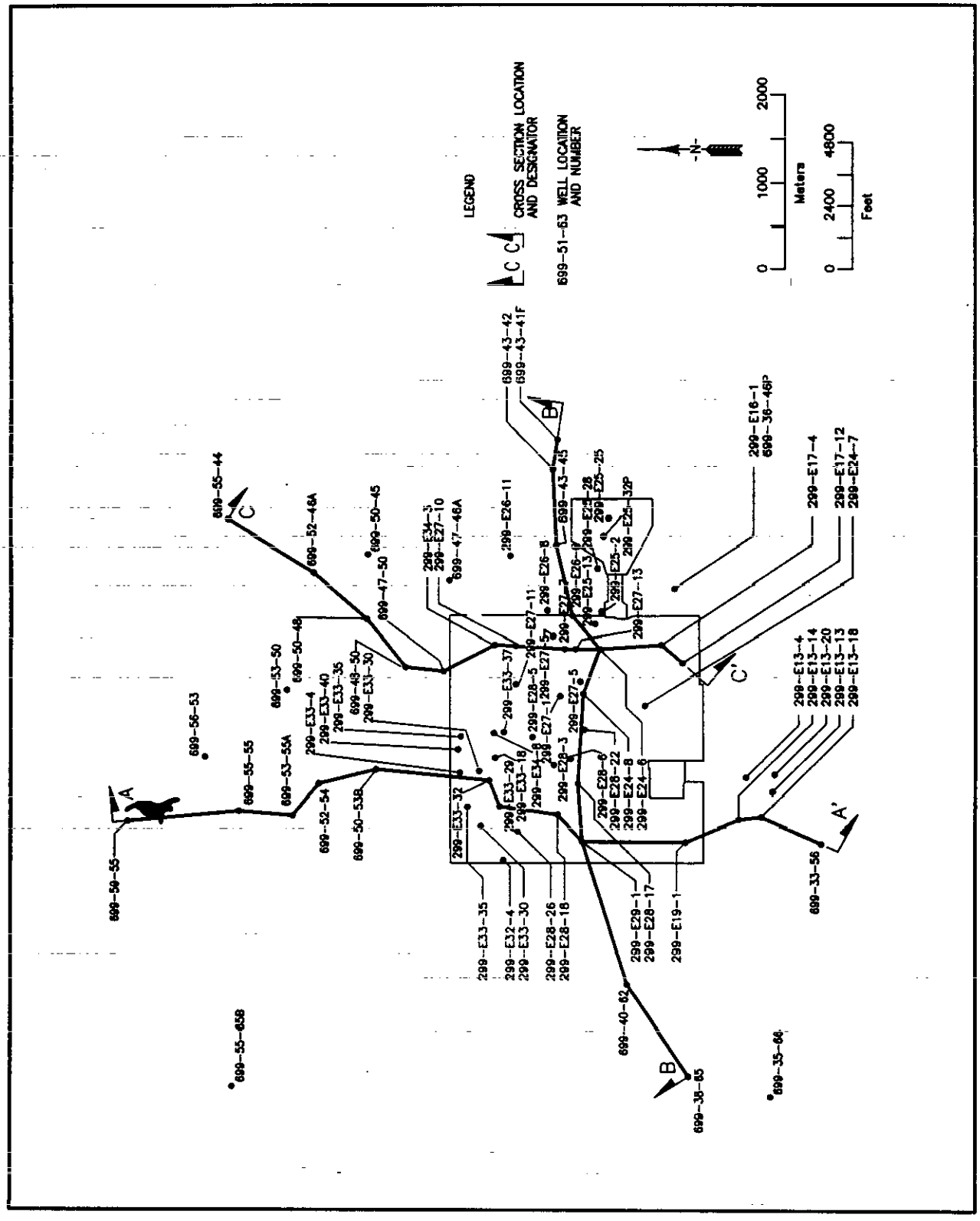
4.1.3 Geology and Stratigraphy of the 200 East Area

Geologic and stratigraphic characteristics distinctive of the 200 East Area are provided in this section. Significant stratigraphic characteristics including thickness variations, dip trends, and spatial relationships are also provided. Stratigraphic units of significance in the 200 East Area include: (1) Pomona Member and Elephant Mountain Members of the Saddle Mountains Basalt; (2) Rattlesnake Ridge interbed of the Ellensburg Formation; (3) Ringold Formation including units A, C, E, the lower mud sequence, and upper Ringold unit; and (4) Hanford formation. Detailed geologic cross sections for the 200 East Area are provided in Figures 4.1-6 through 4.1-9.

4.1.3.1 Pomona and Elephant Mountain Members. The Pomona and Elephant Mountain Members of the Saddle Mountains Basalt are continuous throughout the 200 East Area except in those locations where the Elephant Mountain Member has been removed due to erosion. The Pomona Member ranges from 56 to 60 m (184 to 197 ft) in thickness beneath the 200 East Area. The Elephant Mountain Member generally ranges from 21 to 36 m (69 to 118 ft) in thickness. However, north of the 200 East Area erosional processes have removed the entire section of the Elephant Mountain Member extending from the Gable Mountain-Gable Gap area to the south, terminating near the northern boundary of the 200 East Area.

Studies conducted to date do not indicate the presence of faults or significant fracture systems in the Elephant Mountain Member beneath the 200 East Area. However, a complex fault and fracture system is present to the north of the 200 East Area associated with the Gable Butte-Gable Mountain anticline complex. Generally basalts are composed of various interflow structures that affect their geologic and hydrologic characteristics. Site-specific data on these features for the Pomona and Elephant Mountain Members are not available for the 200 East Area.

Figure 4.1-6. Location of 200 East Area Geologic Cross Sections.



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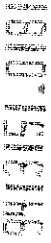
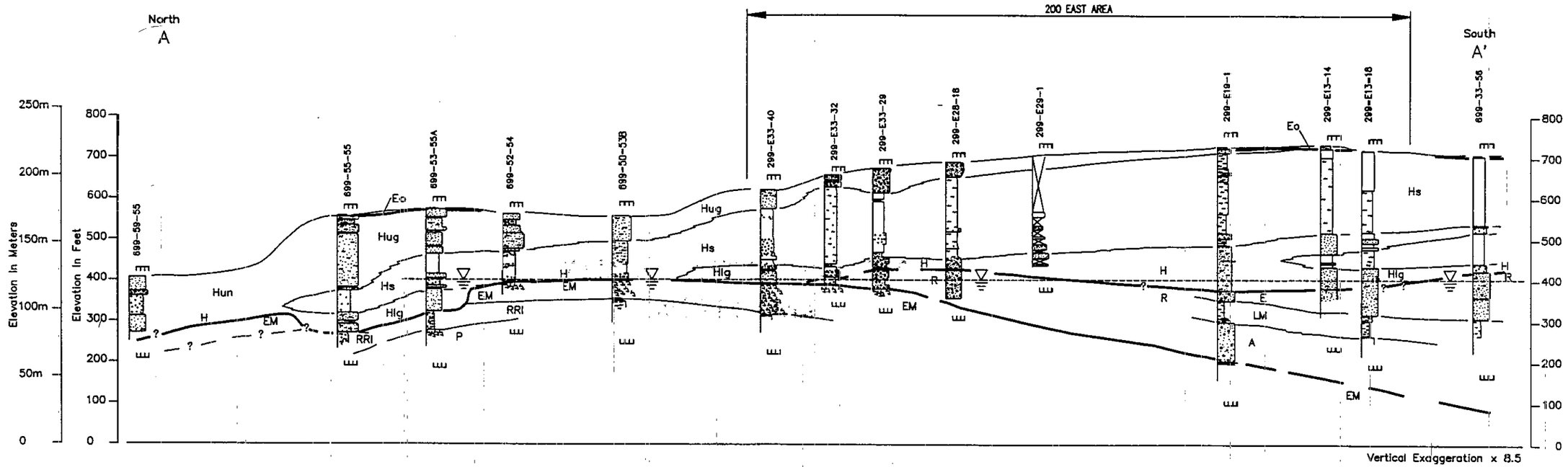


Figure 4.1-7. 200 East Area Geologic Cross Section A-A'.



Scale In Meters
0 500m 1000m 2000m
Scale In Feet
0 1000 2000 3000 4000

NOTE
Refer to Figure 4.1-8 for cross section location and Figure 4.1-3 for legend. Figure based on Lindsey et al. 1992.

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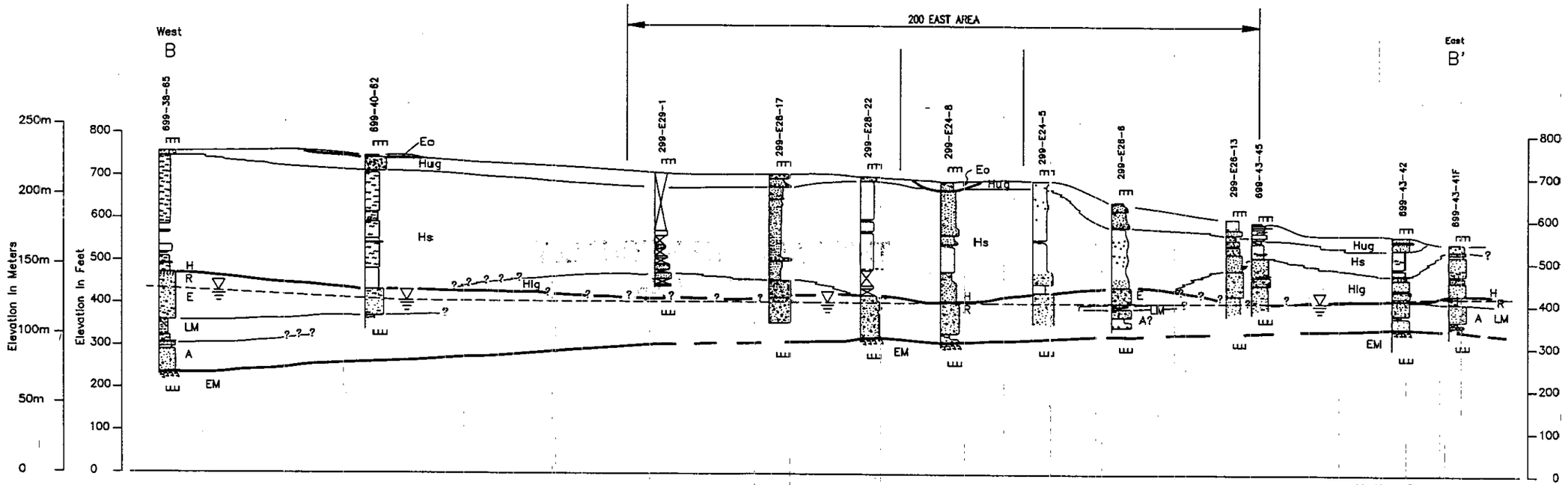
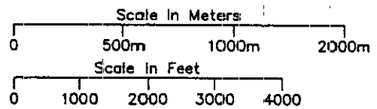
Figure 4.1-8. 200 East Area Geologic Cross Section B-B'.





NOTE
Refer to Figure 4.1-8 for cross section location and Figure 4.1-3 for legend. Figure based on Lindsey et al. 1992.

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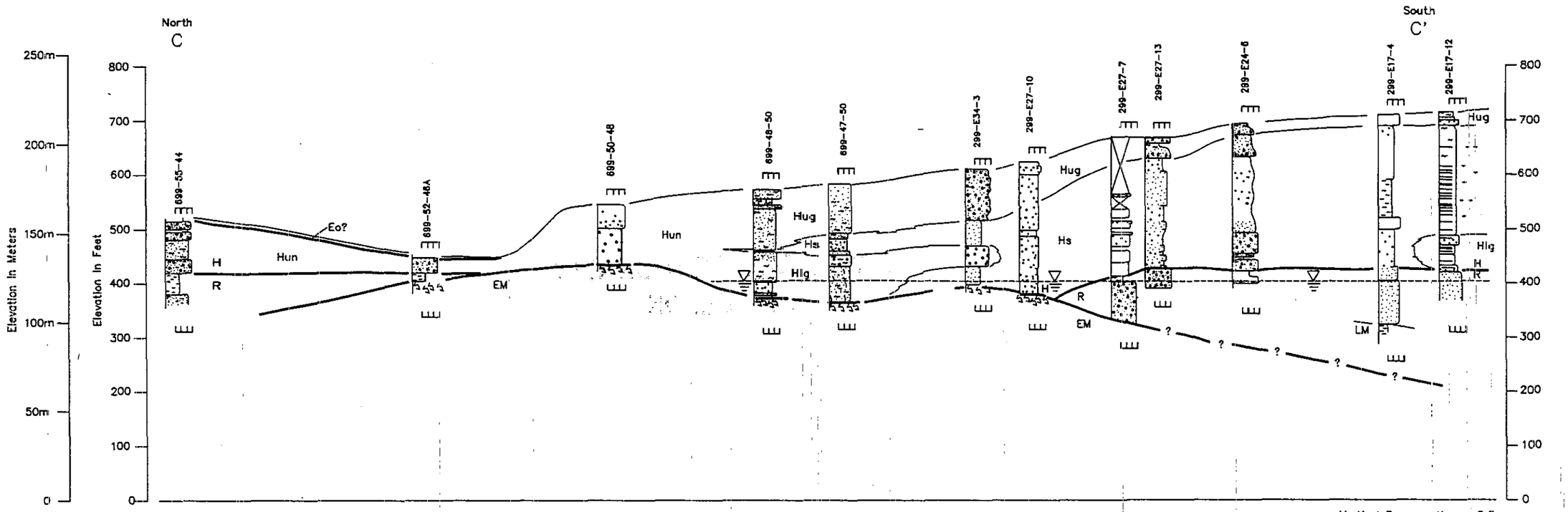
Figure 4.1-9. 200 East Area Geologic Cross Section C-C'.



NOTE
Refer to Figure 4.1-8 for cross section location and Figure 4.1-3 for legend. Figure based on Lindsey et al. 1992.

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4.1.3.2 Rattlesnake Ridge Interbed. The Rattlesnake Ridge interbed forms a sedimentary interbed between the lower Pomona Member and the overlying Elephant Mountain Member. Thickness of the Rattlesnake Ridge interbed ranges from a minimum of 6 m (20 ft) to the north of the 200 East Area, to over 24 m (79 ft) south of the 200 East Area. The Rattlesnake Ridge interbed is composed of fluvially reworked volcanic ash beds and fine- to coarse-grained sand bodies. These sands and ash units are poorly indurated except in those locations of silica cementation and significant low-grade contact metamorphism associated with "baking" of the Rattlesnake Ridge sediments during extrusion of the Elephant Mountain Member basalt flow.

4.1.3.3 Ringold Formation. Beneath the 200 East Area the Ringold Formation is composed of fluvial gravel units A, C, and E; the lower mud sequence; and the upper Ringold unit. Fluvial gravel unit A directly overlies the Elephant Mountain Member. Unit A displays a relatively flat surface that dips to the south and southwest towards the axis of the Cold Creek syncline. Unit A generally pinches out in the central portion of the 200 East Area against structural highs in the underlying basalt bedrock. Thin, lenticular occurrences of unit A are found locally in the area between the northeast 200 East Area and Gable Mountain. Most of the Ringold gravels centrally located in the 200 East Area probably belong to unit A. Intercalated lenticular sand and silt are found locally in the middle section of the unit A gravels in the southeastern portion of the 200 East Area. Unit A ranges in thickness from 0 m (0 ft) in the northern portion of the 200 East Area to greater than 35 m (115 ft) east and south of the 200 East Area.

The fine-grained lacustrine deposits of the lower mud sequence thicken and dip to the southeast in a manner similar to the Ringold fluvial gravel unit A. However, the lower mud sequence is absent throughout much of the central portion of the 200 East Area. The lower mud sequence pinches out against structural highs in the basalt bedrock and, in some locations, is truncated by the overlying Ringold fluvial gravel unit E or Hanford formation. In the region between Gable Mountain and the northern 200 East Area boundary, and in the vicinity of the 216-B-3 Pond system, the lower mud sequence forms the uppermost section of the Ringold Formation and is directly overlain by Hanford formation sediments. Throughout the rest of the 200 East Area the lower mud sequence is overlain by the Ringold fluvial gravel unit E. The lower mud sequence ranges in thickness from 0 m (0 ft) to more than 29 m (95 ft) southeast of the 200 East Area.

Fluvial gravel unit C and the upper Ringold unit are present near the southeast corner of the 200 East Area. These units pinch out immediately north and west but thicken to the south-southwest into the Cold Creek syncline.

Overlying the lower mud sequence is fluvial gravel unit E. This unit thickens to the south and southwest in the 200 East Area. Unit E is restricted primarily to the southern portion of the 200 East Area, and is absent in the 216-B-3 Pond area and between the 200 East Area and Gable Mountain. In addition to the gravels typical of unit E, discontinuous silt and sand lenses are present locally. Unit E reaches a maximum thickness of 35 m (115 ft) south of the 200 East Area.

4.1.3.4 Hanford Formation. The glaciofluvial sands and gravels of the Hanford formation overlie the fluvial and lacustrine sediments of the Ringold Formation in the southern two-thirds of the 200 East Area, but directly overlie basalt bedrock in the northern third and further north of the area where the Ringold Formation is absent. The Hanford formation in the 200 East Area and surrounding localities has been subdivided into three stratigraphic sequences based on texture and grain-size characteristics. These sequences include: (1) the lower gravel sequence, (2) the sandy sequence, and (3) the upper gravel sequence. The lower and upper gravel sequences are composed primarily of gravels typical of the gravel-dominated facies of the Hanford formation. Discontinuous sand and silt beds more typical of the sand- and silt-dominated facies also are sporadically present in these sequences. The sandy sequence, which in most locations stratigraphically separates the lower and upper gravel sequences, contains upward fining packets of fine to coarse sand typical of the sand-dominated facies of the Hanford formation. Sporadic and discontinuous lenses of gravel and silt are also present, which are more representative of the gravel- and silt-dominated facies of the Hanford formation.

The lower gravel sequence is composed of a heterogeneous mix of gravels, sand, and some silt. The sequence ranges in thickness from 0 m (0 ft) to 44 m (144 ft), and is found throughout most of the 200 East Area although it is notably absent in the east-central portion of the 200 East Area and to the west. In locations where the sandy sequence is absent, the lower gravel sequence is directly overlain by the upper gravel sequence. At these locations it is impossible to distinguish the upper sequence from the lower sequence.

The sandy sequence consists of a heterogenous mixture of sand and silt with minor amounts of gravel. Texturally the sandy sequence exhibits graded bedding with multiple packets of fining upward sequences. Fine to coarse sands dominate to the north while silt dominates to the south. Thin lenticular silty paleosols with high carbonate content have been found in the northern part of the 200 East Area within the sandy sequence. The sandy sequence pinches out to the north of the 200 East Area but dips and thickens to the west of the 200 East Area. Maximum thickness of the sandy sequence exceeds 90 m (295 ft) west of the 200 East Area. The sandy sequence is probably correlative with the lower fine-grained sequence of the Hanford formation found in the 200 West Area and as discussed in Section 4.1.2. Clastic dikes are found randomly distributed in the sandy sequence typically oriented in a near-vertical position.

The upper gravel sequence of the Hanford formation consists of a heterogeneous mix of gravels, sand, and some silt, which are similar to the lower gravel sequence. The upper and lower gravel sequences are so similar that without the intervening sandy sequence the upper gravel sequence cannot be distinguished from the lower gravel sequence. The sequence ranges in thickness up to 55 m (180 ft) or more north and possibly west of the 200 East Area. In the northern portion of the 200 East Area the upper gravel sequence forms an elongate, northwest to southeast-trending gravel tract. North of the 200 East Area the upper gravel sequence cannot be distinguished from the lower sequence because of the absence of the sandy sequence. The upper gravel

sequence thins to about 4 m (13 ft) just north of the B Plant area and is not present in the east-central portion of the 200 East Area. Clastic dikes have been observed crosscutting this sequence.

4.1.4 Hydrogeology of the 200 West Area

The two major hydrogeologic units of interest are the vadose zone and the uppermost aquifer. The following discussion provides further detail on the composition, thickness, and hydraulic properties of the vadose zone and uppermost aquifer beneath the 200 West Area. A conceptual model of the 200 West Area hydrostratigraphy is illustrated in Figure 4.1-10.

4.1.4.1 200 West Area Vadose Zone Characteristics. The vadose zone in the 200 West Area is composed of the Holocene surficial deposits, the Hanford formation, the Plio-Pleistocene/"early" Palouse soil interval, the upper Ringold unit, and the upper section of the Ringold fluvial gravel unit E. Thickness of the vadose zone ranges from less than 50 m (164 ft) near the southwest corner of the area to over 100 m (328 ft) in the northwest corner.

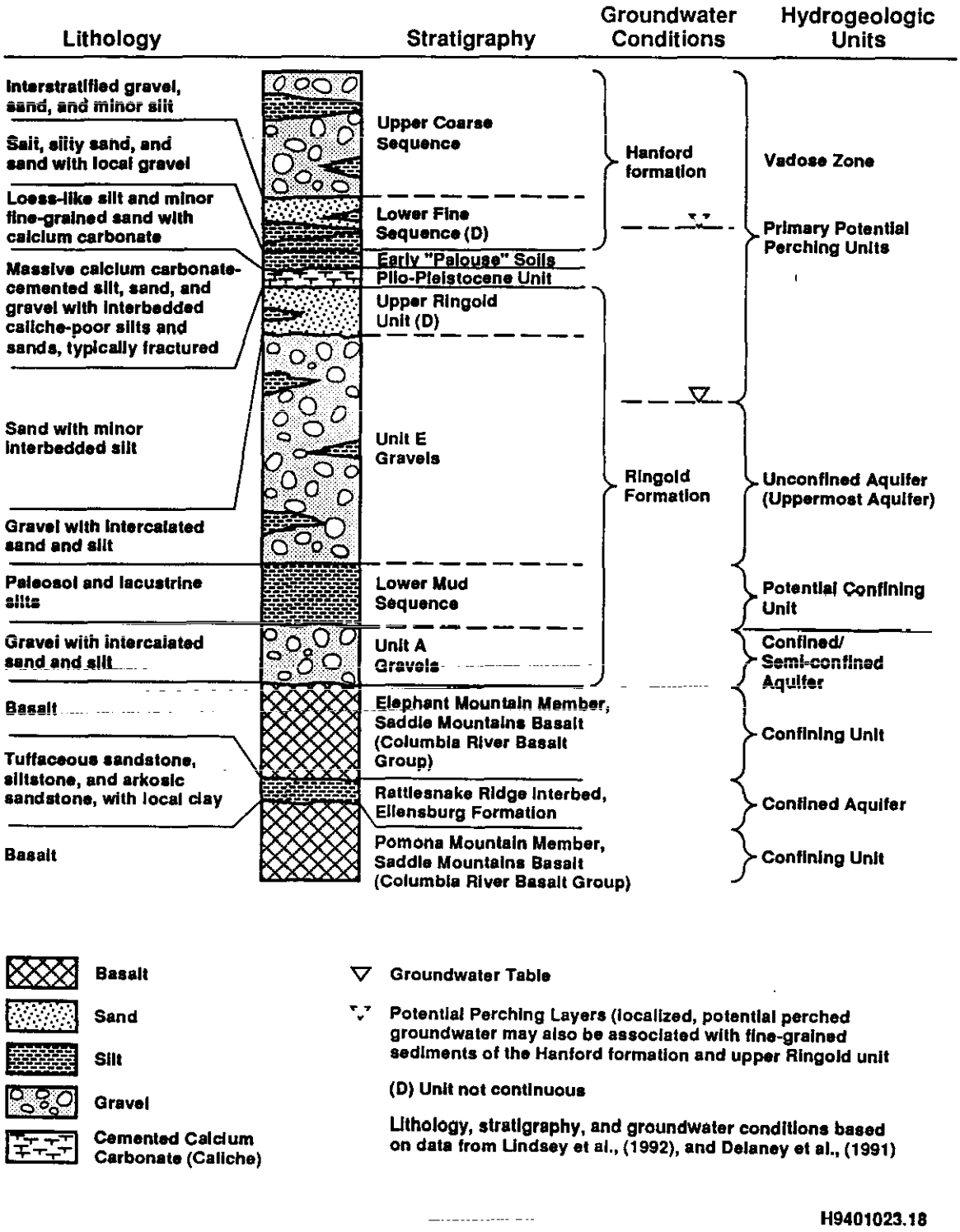
Flow of water through the vadose zone is a function of the relationship between recharge rates, moisture content, matric potential, and unsaturated hydraulic conductivity for each hydrostratigraphic unit. In the 200 West Area, recharge rates are governed by both artificial and natural sources with artificial sources greatly dominating the flux of water through the vadose zone near active liquid waste disposal facilities.

In general, water will flow and spread laterally at a much greater rate in the fine-grained units than in coarse-grained units under unsaturated conditions. Fine-grained units in the Hanford formation, the "early" Palouse soil, the Plio-Pleistocene unit, and the upper Ringold unit significantly influence the lateral distribution and flux of water to the uppermost aquifer in the 200 West Area. Measured saturated hydraulic conductivities for the fine-grained units are highly variable ranging from 10^{-4} to 10^{-7} cm/s (1 to 10^{-3} ft/d) (Connelly et al. 1992a).

Coarse-grained units may impede the flux of water through the vadose zone under unsaturated flow conditions because of the formation of a capillary pressure barrier between the coarse-grained units and overlying fine-grained units. The Hanford formation coarse-grained sequence and the Ringold fluvial gravel unit E could potentially induce a capillary pressure barrier effect under favorable hydraulic conditions. Typically, lateral dispersion of water is minimal in the coarse-grained units in the 200 West Area. Measured saturated hydraulic conductivities for the coarse-grained hydrostratigraphic units range from 10^{-2} to 10^{-6} cm/s (10 to 10^{-2} ft/d) for gravel units containing a large percentage of fine-grained matrix (Connelly et al. 1992a).

The fine-grained units have produced perched water conditions in the vadose zone beneath the 200 West Area near active liquid waste facilities. The Plio-Pleistocene/"early" Palouse soil interval appears to be the primary perching units throughout most of the 200 West Area. In the south, the lower fine-grained sequence of the Hanford formation also may produce perched water

Figure 4.1-10. Generalized Hydrostratigraphy of the 200 West Area.



conditions near active facilities. Perched water is known to exist near the active portion of the 216-U-14 Ditch, the 216-Z-20 Crib, and the 216-Z-21 Seepage Basin. Perched water zones at other localities in the 200 West Area may exist resulting from past and present disposal of wastewater to various waste management units and septic drain fields.

4.1.4.2 200 West Area Uppermost Aquifer Characteristics. Generally the uppermost aquifer in the 200 West Area is unconfined and contained within the Ringold fluvial gravel unit E. The lower mud sequence forms the base of the uppermost aquifer throughout most of the 200 West Area, except in the extreme northern region of the area where the lower mud sequence is absent. In this region the Ringold fluvial gravel unit A is considered part of the uppermost aquifer and the Elephant Mountain Member forms the base of the aquifer. The thickness of the uppermost aquifer ranges from 40 to 80 m (131 to 262 ft) in the 200 West Area. Recent drilling and monitoring well installation activities near the northern border of the 200 West Area have discovered significant carbonate-cemented zones in unit E of the Ringold Formation. These zones have produced semiconfining conditions near the top of the water table resulting from carbonate cementation and the associated reduction in permeability. The lateral persistency and competence of the cemented zones is uncertain.

Hydraulic properties of the uppermost aquifer vary significantly in the 200 West Area. Horizontal hydraulic conductivity values range from 0.093 to 475 m/d (0.3 to 1,558 ft/d) for the upper portion of the uppermost aquifer system. Vertical hydraulic conductivity values have been found to range from 8.6×10^{-5} to 2.2 m/d (2.8×10^{-4} to 7 ft/d) (Connelly et al. 1992a). Figure 4.1-11 is a hydraulic conductivity map for the 200 West Area. This map illustrates gross trends in hydraulic conductivity in the upper 10 m (33 ft) of the uppermost aquifer, and highlights the high degree of variability in hydraulic conductivity for the 200 West Area.

4.1.4.3 Groundwater Flow Characteristics in the 200 West Area. Groundwater flow in the uppermost aquifer beneath the 200 West Area is dominantly controlled by the groundwater mound that developed beneath the 216-U-10 Pond. In 1984, the discharges to the 216-U-10 Pond were terminated and the 216-U-10 Pond was decommissioned. In response, water levels in the uppermost aquifer have begun to dissipate rapidly throughout the 200 West Area. A hydrograph of water levels collected from wells located at various locations in the 200 West Area is provided in Figure 4.1-12. The hydrograph illustrates the historical water level trends in the uppermost aquifer and highlight the recent decrease in water levels observed throughout the 200 West Area. In addition to the decrease in water levels, the mound has appeared to move in a northeasterly direction over time. This apparent movement is probably due to continued drainage from the currently active 216-Z-20 Crib and the 216-U-14 Ditch, which are located northeast of the 216-U-10 Pond.

The June 1993 water table map for the uppermost aquifer beneath the 200 Areas is provided in Figure 4.1-13. The water table map illustrates the hydraulic control exerted by the decaying groundwater mound. Radial groundwater flow directed away from the mound produces flow directions with and against the regional groundwater flow direction.

Figure 4.1-11. Hydraulic Conductivity Map for the 200 West Area (modified from Connelly et al. 1992a).

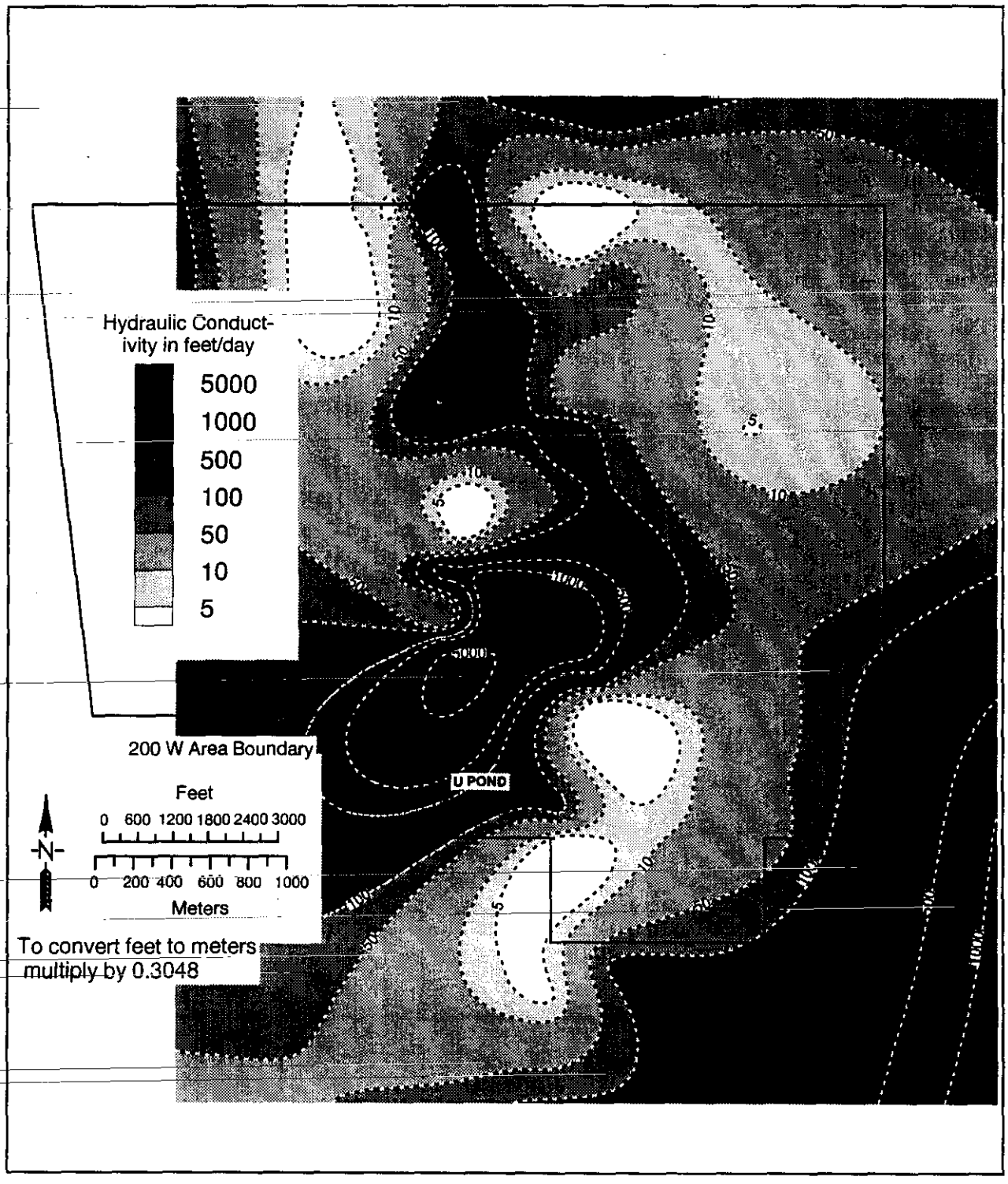


Figure 4.1-12. Hydrograph of Historical Water Level Trends in the Uppermost Aquifer in the 200 West Area.

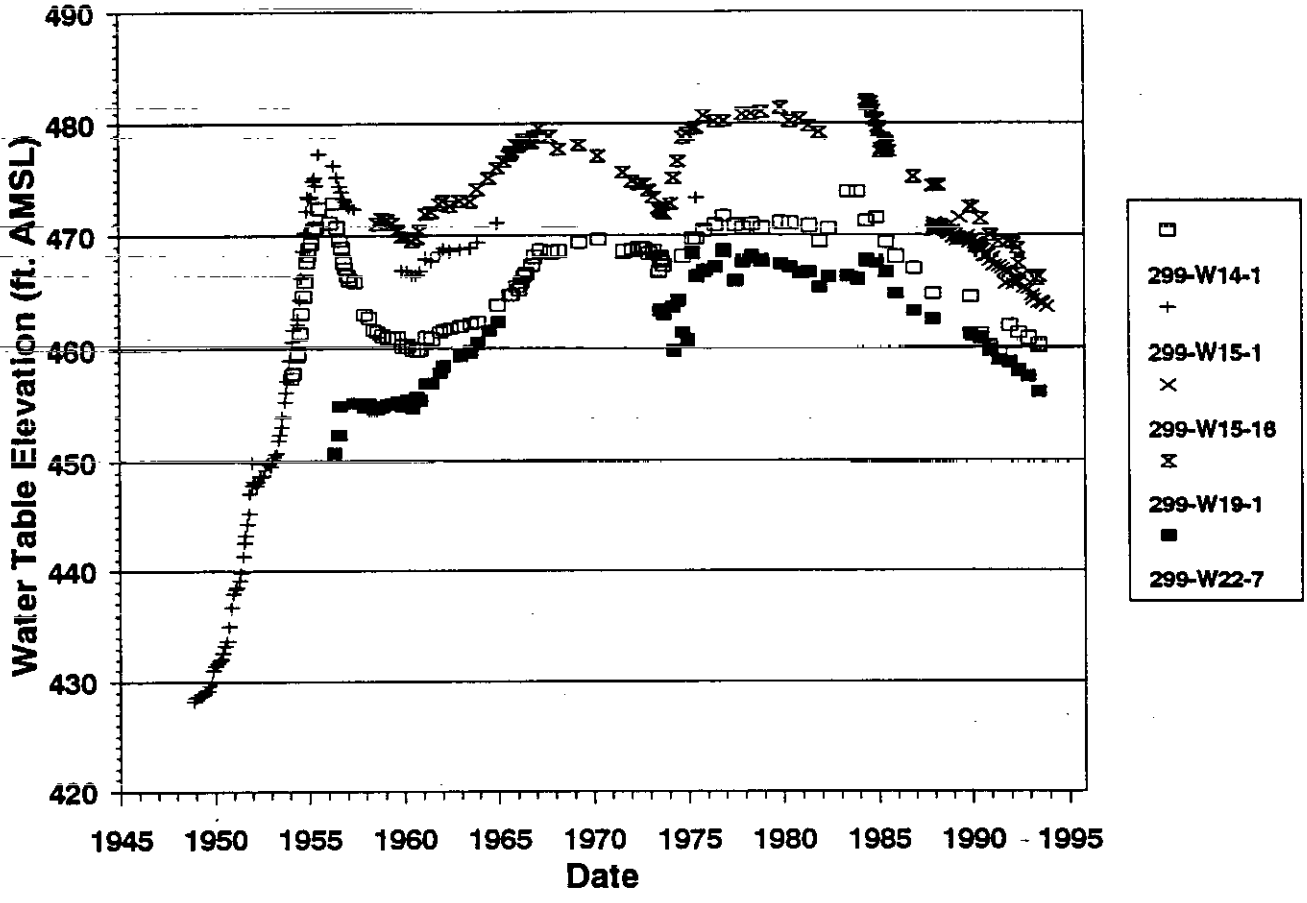


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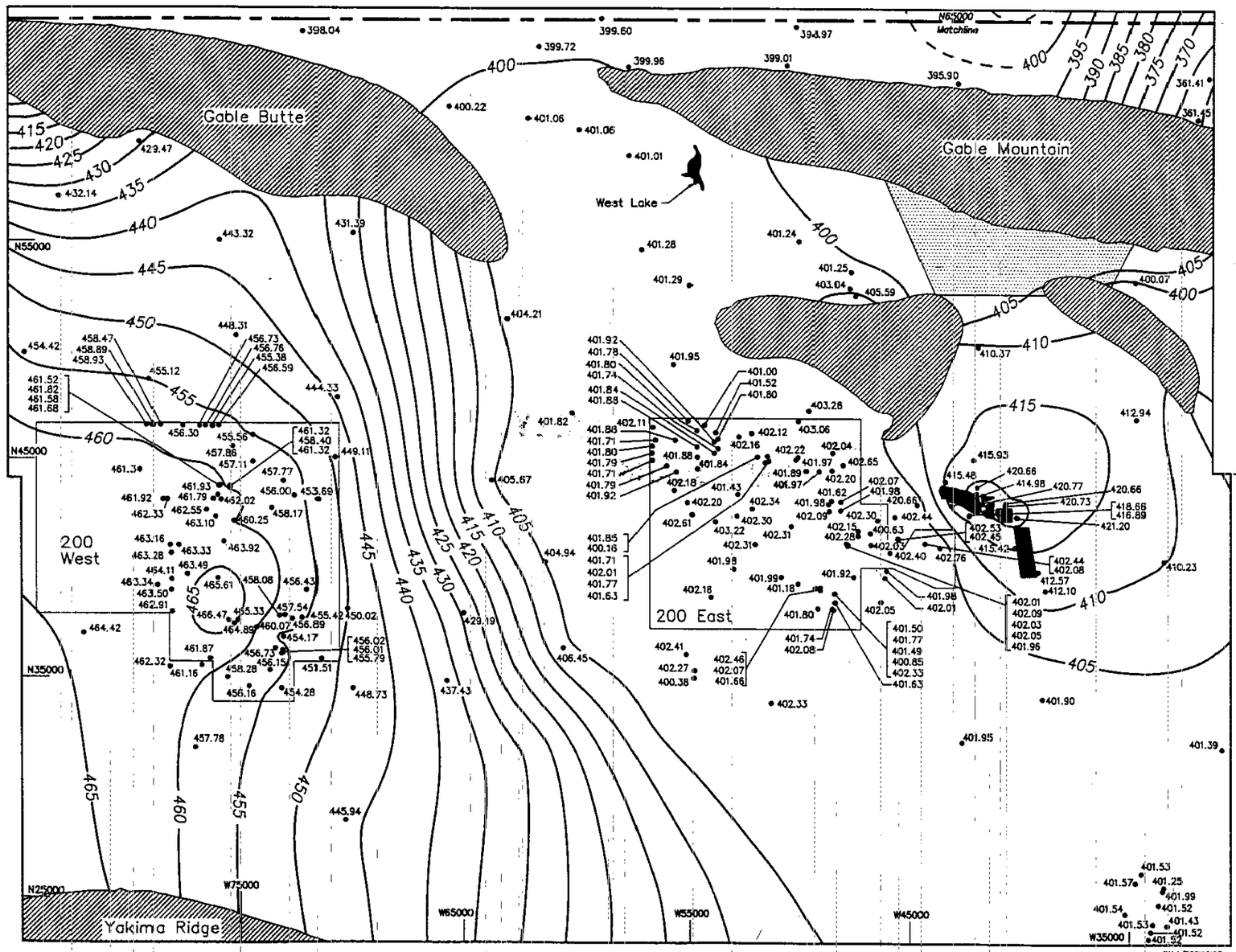
Figure 4.1-13. - 200 Area Water Table Map, June 1993.



200 Areas Water Table Elevation June 1993

402.49 Water Table elevation (feet above mean sea level)

405 Water table elevation Contour Interval = 5 ft

Ponds

Areas where the basalt surface is generally above the water table

Area of conflicting data

The 200 Areas water table elevation map has been prepared by the Geohydrologic Engineering Function, Westinghouse Hanford Company.

Note: To convert to metric, multiply elevation (ft) by 0.3048 to obtain elevation (m).

0 1 Mile

0 1 Kilometer

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4.1.5 Hydrogeology of the 200 East Area

The two major hydrogeologic units of interest are the vadose zone and the uppermost aquifer. The following discussion provides further detail on the composition, thickness, and hydraulic properties of the vadose zone and uppermost aquifer beneath the 200 East Area. A conceptual model of the 200 East Area hydrostratigraphy is illustrated in Figure 4.1-14.

4.1.5.1 200 East Area Vadose Zone Characteristics. The vadose zone in the 200 East Area is composed primarily of Holocene surficial deposits, the Hanford formation, the Ringold fluvial gravel units A and E, the Ringold lower mud sequence, and basalt in some locations. Because of the discontinuous nature of the Ringold Formation north of the central portion of the 200 East Area, the vadose zone is dominated by the Hanford formation sediments between the 200 East Area and Gable Mountain-Gable Gap. In areas where the basalt rises above the water table elevation the basalt is included as a hydrostratigraphic unit in the vadose zone. The lower mud sequence of the Ringold Formation composes the lower portion of the vadose zone beneath and surrounding the 216-B-3 Pond system in the eastern portion of the 200 East Area, and to the areas north and northeast of the 216-B-3 Pond. Thickness of the vadose zone in the 200 East Area ranges from 104 m (341 ft) near the southern border of the area to 37 m (121 ft) thick near the 216-B-3 Pond system.

Flow of water through the vadose zone is a function of the relationship between recharge rates, moisture content, matric potential, and unsaturated hydraulic conductivity for each hydrostratigraphic unit. In the 200 East Area, recharge rates are governed by both artificial and natural sources, with artificial sources greatly dominating the flux of water through the vadose zone near active liquid waste disposal facilities. Natural recharge rates range from 0.1 to 10 cm/yr (0.039 to 3.9 in./yr), depending on surface soil type and vegetation cover.

Generally water will flow and spread laterally at a much greater rate in the fine-grained units than in coarse-grained units under unsaturated conditions. Fine-grained units in the Hanford formation and the lower mud sequence of the Ringold Formation significantly influence the lateral distribution and flux of water to the uppermost aquifer in the 200 East Area. Measured saturated hydraulic conductivities for the lower mud sequence are on the order of 10^{-8} cm/s (10^{-4} ft/d). The sandy sequence of the Hanford formation exhibits much more variability in saturated hydraulic conductivity, ranging from 10^{-2} to 10^{-5} cm/s (10^{2} to 10^{-1} ft/d) (Connelly et al. 1992b).

Coarse-grained hydrostratigraphic units may impede the flux of water through the vadose zone under unsaturated flow conditions because of the formation of a capillary barrier between the coarse-grained units and overlying fine-grained units. The Hanford lower and upper gravel sequences and Ringold fluvial gravel units A and E could potentially induce a capillary barrier effect under favorable hydraulic conditions. Typically, lateral dispersion of water is minimal in the coarse-grained units in the 200 East Area. Measured saturated hydraulic conductivities for the coarse-grained hydrostratigraphic units range from 10^{-2} to 10^{-6} cm/s (10^{2} to 10^{-2} ft/d) for gravel units containing a large percentage of fine-grained matrix (Connelly et al. 1992b).

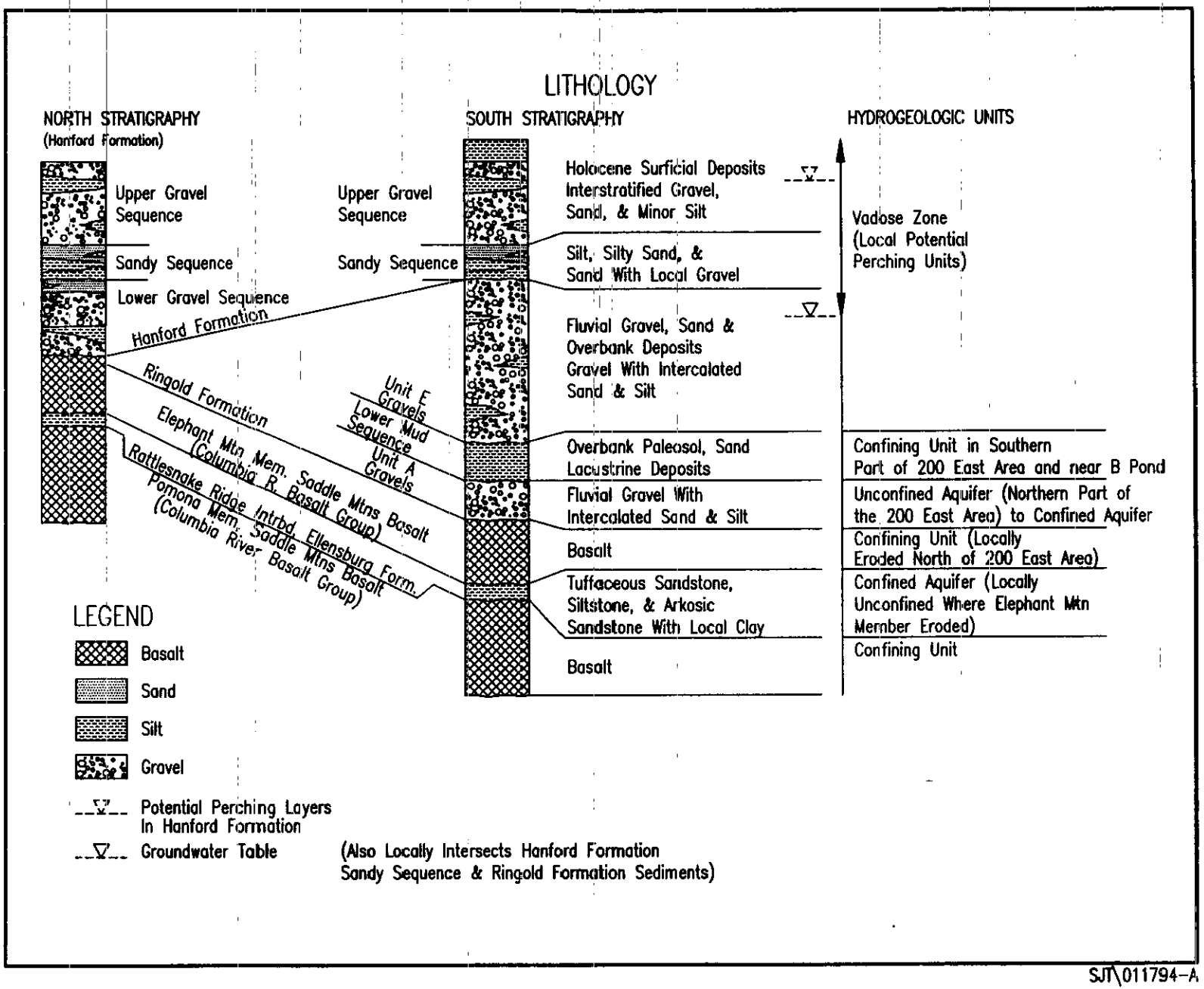


Figure 4.1-14. Generalized Hydrostratigraphy of the 200 East Area.

The fine-grained hydrostratigraphic units in the 200 East Area could potentially produce perched water conditions in the vadose zone near active liquid waste facilities. The fine-grained paleosols and silts found in the sandy sequence of the Hanford formation may have produced perching conditions in the past, although these units typically are not laterally persistent. Current locations of perched water associated with the fine-grained units in the sandy sequence of the Hanford formation exist to the east of the 241-BY Tank Farm. To the east, the lower mud sequence of the Ringold Formation also produces perched water conditions in the vicinity of the 216-B-3 Pond system and the W-049H Treated Effluent Disposal Basins (Davis et al. 1993).

4.1.5.2 200 East Area Uppermost Aquifer Characteristics. In contrast to the 200 West Area, the hydrogeology of the 200 East Area is relatively complex because of the depositional and erosional history of the area. The uppermost aquifer in the 200 East Area generally is unconfined, but also exhibits confined to semiconfined conditions in the eastern portion of the 200 East Area. The aquifer is contained primarily in the Hanford formation and the Ringold Formation throughout most of the 200 East Area. North of the 200 East Area the Rattlesnake Ridge interbed forms the lower portion of the uppermost aquifer where the Elephant Mountain Member has been removed by erosional processes. The base of the uppermost aquifer is variable. In the northern portion of the 200 East Area the Elephant Mountain Member forms the base of the uppermost aquifer except where it has been removed by erosion. In these locations the Pomona Member provides the base for the uppermost aquifer. In the south and eastern portions of the 200 East Area the lower mud sequence of the Ringold Formation provides the base for the uppermost aquifer. Elsewhere, the Elephant Mountain Member forms the base of the uppermost aquifer, excluding those locations to the north where erosional processes have removed the Elephant Mountain Member. In these locations the Pomona Member forms the base of the uppermost aquifer. The thickness of the uppermost aquifer ranges from 0 m (0 ft) where the basalt bedrock lies above the static water level to the north, to greater than 60 m (197 ft) in the south and west portions of the 200 East Area.

In locations where the Elephant Mountain Member has been removed by erosion, the uppermost aquifer is in direct hydraulic communication with the Rattlesnake Ridge aquifer. In the past, the hydraulic head in the uppermost aquifer has been greater than the hydraulic head in the Rattlesnake Ridge aquifer. As a result, groundwater contaminants contained in the uppermost aquifer were advectively transported into the Rattlesnake Ridge aquifer at those locations of direct hydraulic communication. Current conditions are such that the Rattlesnake Ridge aquifer exhibits a slightly greater hydraulic head compared to the uppermost aquifer throughout most of the 200 East Area (Connelly et al. 1992b). This greatly reduces or negates the flux of additional dissolved contaminants from the uppermost aquifer into the Rattlesnake Ridge aquifer. However, a downward hydraulic gradient does exist in the vicinity of the 216-B-3 Pond system due to the mounding of groundwater in the uppermost aquifer beneath the facility. Hydraulic head in the uppermost aquifer beneath the 216-B-3 Pond exceeds the hydraulic head in the Rattlesnake Ridge aquifer by approximately 6 m (20 ft).

The uppermost aquifer is under unconfined conditions throughout most the 200 East Area. However, in the near vicinity of the 216-B-3 Pond system, the uppermost aquifer becomes confined to semiconfined beneath the lower mud sequence of the Ringold Formation. At this location the lower mud sequence is considered part of the vadose zone while the groundwater beneath the lower mud sequence is under artesian conditions. Water has been encountered overlying the lower mud sequence at this location, but these bodies of water are considered to be perched water zones and not part of the uppermost aquifer.

Hydraulic properties of the uppermost aquifer vary significantly in the 200 East Area. Horizontal hydraulic conductivity values range from 8 to 7,600 m/d (26 to 24,934 ft/d) for the upper portion of the uppermost aquifer system (Connelly et al. 1992b). Figure 4.1-15 is a hydraulic conductivity map for the 200 East Area. This map illustrates gross trends in hydraulic conductivity in the upper 10 m (33 ft) of the uppermost aquifer, and highlights the high degree of variability in hydraulic conductivity for the 200 East Area.

4.1.5.3 Groundwater Flow Characteristics in the 200 East Area. The 216-B-3 Pond system significantly influences groundwater flow direction and hydraulic gradients in the uppermost aquifer throughout the 200 East Area. Although the 216-B-3 Pond is still active, a decrease in the volume of wastewater disposed to the 216-B-3 Pond has affected water levels in the uppermost aquifer throughout the 200 East Area. In general, water levels in the uppermost aquifer have decreased in response to the reduction in effluent volume disposed to the 216-B-3 Pond system as well as the reduction or cessation of effluent disposal to various other facilities in the 200 East Area. The hydrograph presented in Figure 4.1-16 illustrates the recent water level decreases with respect to the historical water level trends throughout the 200 East Area.

The June 1993 water table map for the uppermost aquifer beneath the 200 Areas is illustrated in Figure 4.1-13. Groundwater flow in the 200 East Area is characterized by relatively flat hydraulic gradients except in the vicinity of the 216-B-3 Pond system. Near the 216-B-3 Pond system groundwater flows radially outward because of mounding beneath the 216-B-3 Pond. The groundwater mound and associated radial groundwater flow pattern produces a flattening of the hydraulic gradient throughout most of the 200 East Area. In addition, a groundwater divide has developed where eastward flowing groundwater is deflected to the southeast and northwest resulting from the groundwater mound beneath the 216-B-3 Pond system.

4.1.6 Groundwater Chemistry in the 200 Areas

Groundwater chemistry in the uppermost aquifer beneath the 200 Areas has been affected by various reactor fuel processing and waste management activities that have been conducted since Hanford Site operations began in the 1940's. Ten contaminants present today beneath *Resource Conservation and Recovery Act of 1976* (RCRA) and solid waste facilities are discussed in this section. This discussion is presented as background information to the individual facility evaluations contained in this report. The plumes

Figure 4.1-15. Hydraulic Conductivity Map for the 200 East Area.

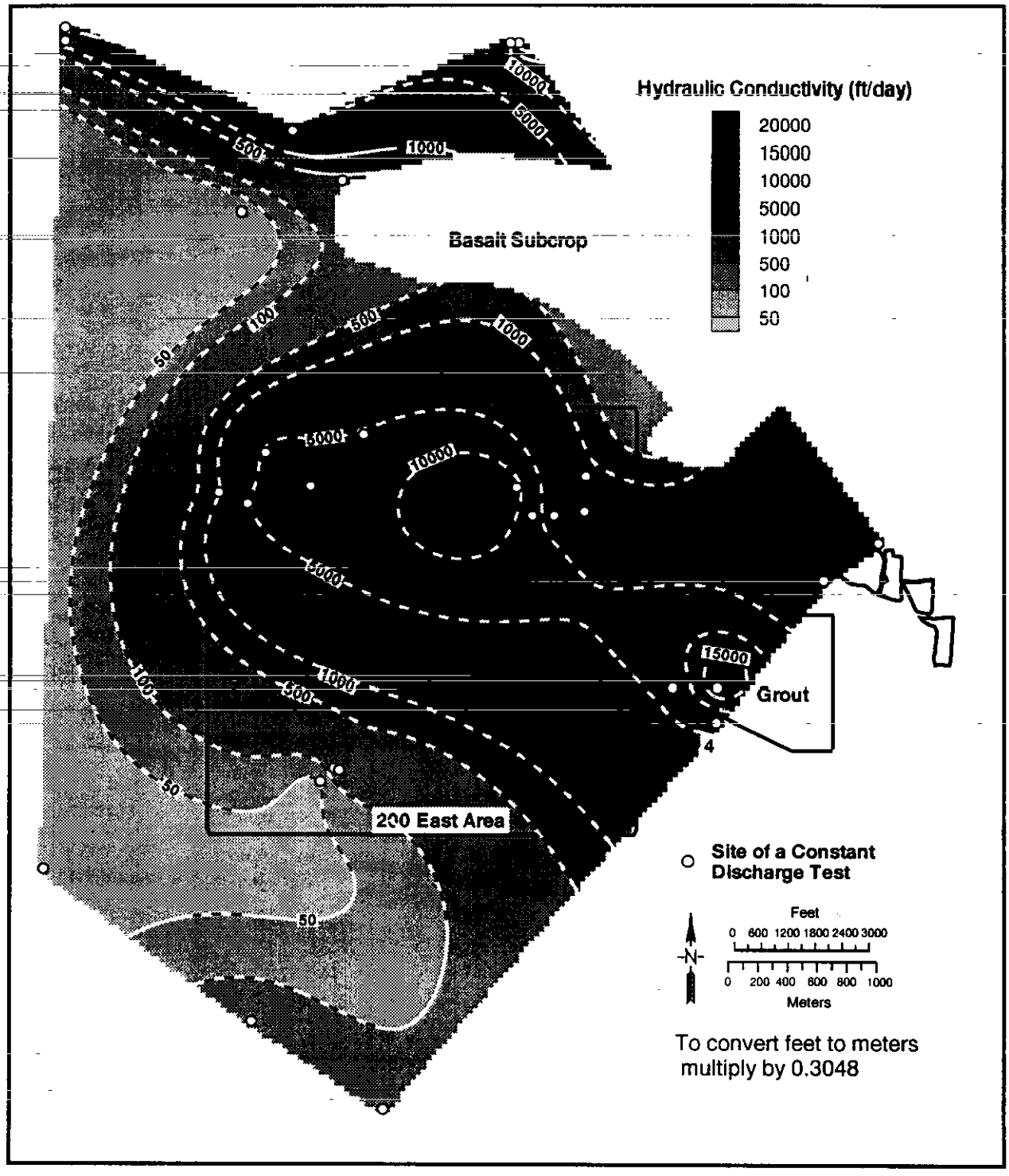
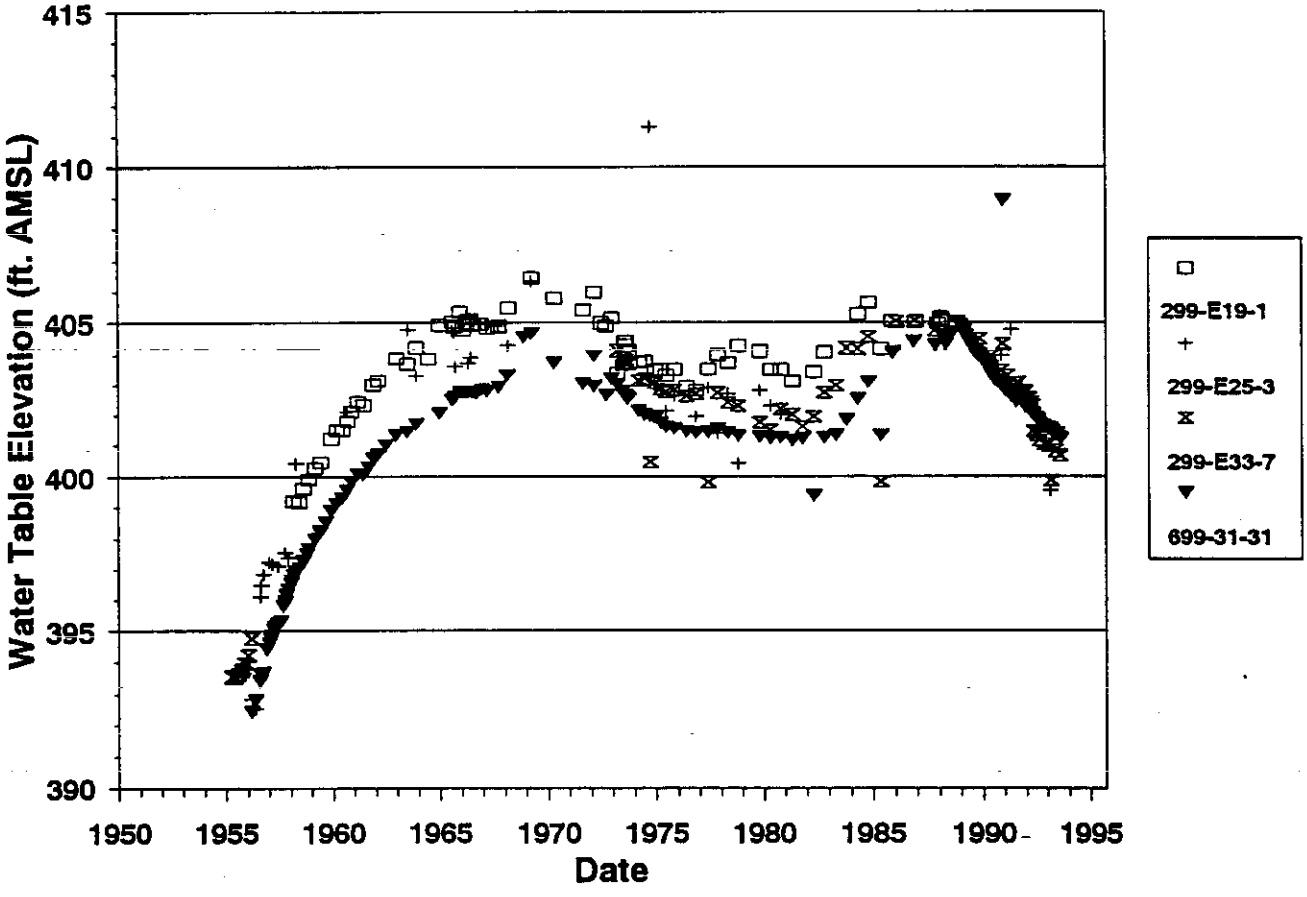


Figure 4.1-16. Hydrograph of Historical Water Level Trends in the Uppermost Aquifer Near Plutonium-Uranium Extraction Plant Liquid Waste Disposal Units.



discussed in this section have many different sources, many of which are not RCRA or solid waste facilities. Discussions of the individual plumes are ordered as follow:

- Metals--arsenic
- Anions--nitrate
- Volatile organics--carbon tetrachloride (CCl_4), chloroform, and trichloroethylene (TCE)
- Tritium
- Beta-emitting radionuclides--gross beta, ^{99}Tc, and ^{129}I
- Alpha-emitting radionuclides--gross alpha.

Additional contaminants have been identified and mapped in the *Groundwater Field Characterization Report for the 200 Aggregate Area Management Study* (WHC 1993a).

The primary objective of each contaminant map is to illustrate the extent of the plume that exceeds the most stringent regulatory standard that is applicable to the contaminant. The standards have been noted in the legend for each map. In some cases, the detection limit (DL) or minimum detectable concentration (MDC) is greater than the most stringent standard (e.g., arsenic, CCl_4, and TCE). In each of these cases, the minimum isopleth has been selected at a value close to the DL. Plumes that are defined by only one well are identified in discussions as potential plumes.

To illustrate the potential extent of some contaminant plumes (e.g., tritium and ^{99}Tc), an extra contour less than the most stringent regulatory standard has been added. When such a contour is included, a dashed line has been used to help distinguish it from the standard-exceeding contours.

4.1.6.1 Metals.

4.1.6.1.1 Arsenic (filtered). The Washington Water Quality Standard (WWQS) for arsenic is 0.05 ppb (*Washington Administrative Code* [WAC] 173-200). This value is two orders of magnitude less than the detection limit (5 ppb) and three orders of magnitude more stringent than the drinking water standard (DWS) and maximum contaminant level (MCL) of 50 ppb. Arsenic contamination is illustrated in Figure 4.1-17. The only regulatory standard that is exceeded in any of the wells in the 200 Areas is the WWQS.

Two plumes of contamination and two potential plumes are identified beneath the 200 West Area. The maximum average concentration in 200 West Area wells occurs in well 2-W18-29 (23 ppb).

A large plume of slightly elevated arsenic contamination is present beneath the northeastern half of the 200 East Area. Average detections within the plume range between 6 and 15 ppb.

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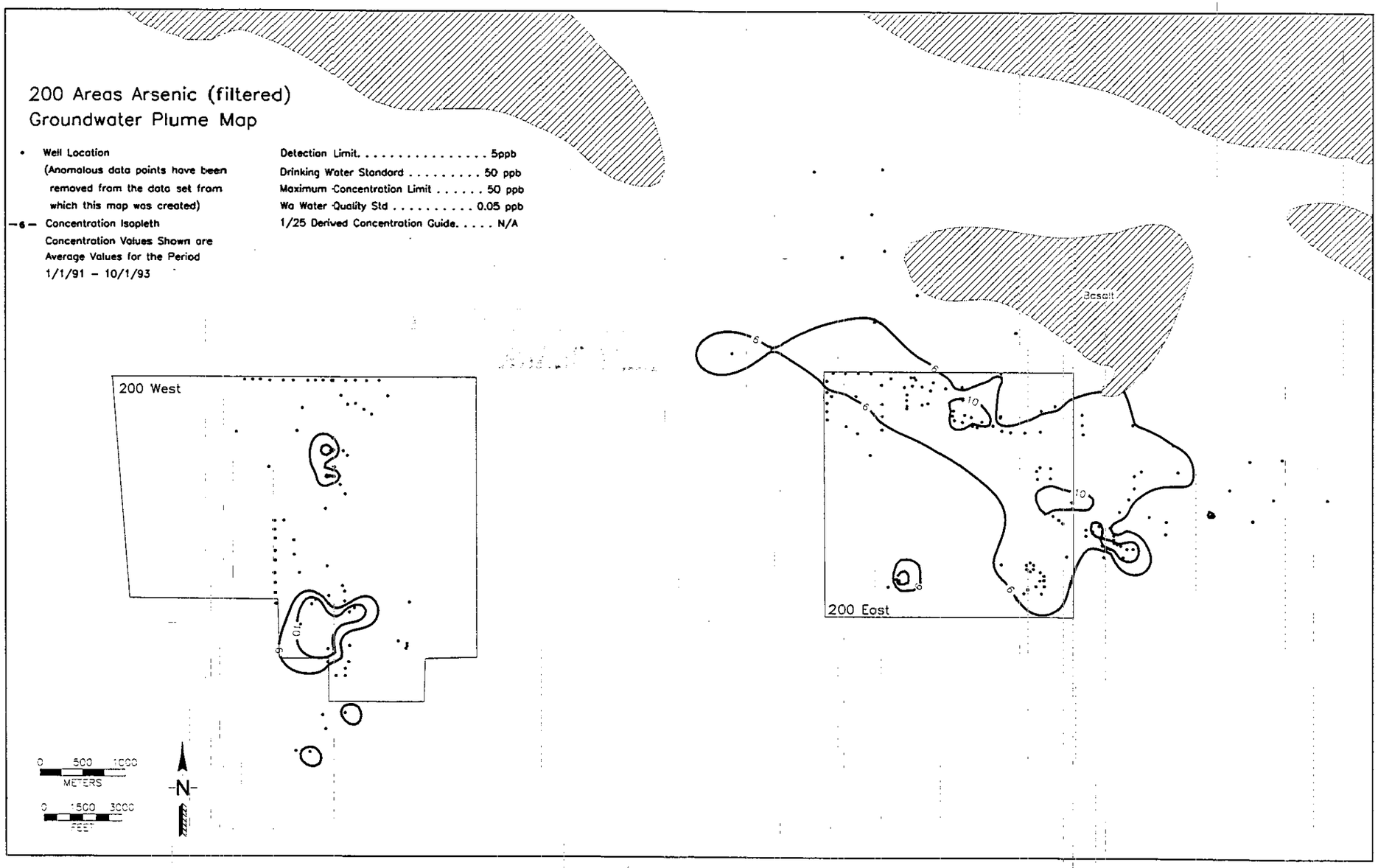
Figure 4.1-17. Arsenic Distribution in the Uppermost Aquifer Beneath the 200 Area (Filtered Analyses).



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4.1.6.2 Anions.

4.1.6.2.1 Nitrate. Nitrate contamination (>45,000 ppb) is widespread in the 200 West Area with smaller plumes in and north of the 200 East Area (Figure 4.1-18). The contamination from the 200 West Area has been transported far beyond the eastern boundary of the area. Insufficient wells have been installed in this area immediately west of the 200 East Area to assess the potential for this plume to have reached the border of the 200 East Area. The same problem exists in the interpretation of the extent of tritium contamination (Section 4.1.6.4).

The highest average concentrations for nitrate in the 200 West Area are in well 2-W19-19 (1,175,000 ppb). The well monitors the 216-U-17 Crib, an active facility; however, the contamination predates the initial use of the crib (WHC 1993a). The contamination appears to be related to an upgradient source, either the 216-U-1 and 216-U-2 Cribs or leakage from an effluent transfer line that runs to the 216-U-8 and 216-U-12 Cribs (inactive since 1988). The high nitrate values in the vicinity of this well coincide with elevated uranium and ^{99}Tc.

The highest average concentration of nitrate in wells in the eastern half of the 200 Areas occurs in well 6-50-53A (440,000 ppb), which is located just to the north of the 200 East Area. The contamination appears to be the result of the disposal of scavenged uranium recovery wastes to the BY Cribs in the 200 East Area during the 1950's. Two plumes located in the southeastern corner of the 200 East Area are centered on wells that monitor facilities that have at some time received effluent from Plutonium-Uranium Extraction (PUREX) Plant or the 242-A Evaporator. The maximum average contamination occurs in well 299-E25-13 (293,000 ppb). A one-well potential contaminant plume is indicated in the northwestern corner of the 200 East Area. A two-well plume is defined just north of the basalt subcrop (hachured area northeast of 200 East Area) in the vicinity of the decommissioned Gable Mountain Pond. The contaminant levels are just barely above the DWS.

4.1.6.3 Volatile Organics.

4.1.6.3.1 Carbon Tetrachloride. The contaminant plume illustrated in Figure 4.1-19 is based on contaminant monitoring performed in support of the *Expedited Response Action Proposal (EE/CA & EA) for 200 West Area Carbon Tetrachloride Plume* (DOE 1991). The most stringent limit for this constituent is 0.3 ppb (WWQS), which is well below the 5-ppb DL. The minimum contaminant isopleth illustrated in the figure is 10 ppb. Discussion of potential source facilities for the CCl_4 contamination is contained in DOE (1991).

4.1.6.3.2 Chloroform. Figure 4.1-20 illustrates the extent of chloroform contamination beneath the 200 Areas. One large plume of contamination in excess of the WWQS standard of 7 ppb is defined beneath the 200 West Area and two one-well potential plumes, one each beneath the 200 East and 200 West Areas. The large plume occurs in the same approximate area as the core of the CCl_4 plume (see Figure 4.1-19). The maximum average value in the plume is 407 ppb (well 2-W11-30).

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Figure 4.1-18. Nitrate Distribution in the Uppermost Aquifer Beneath the 200 Area.

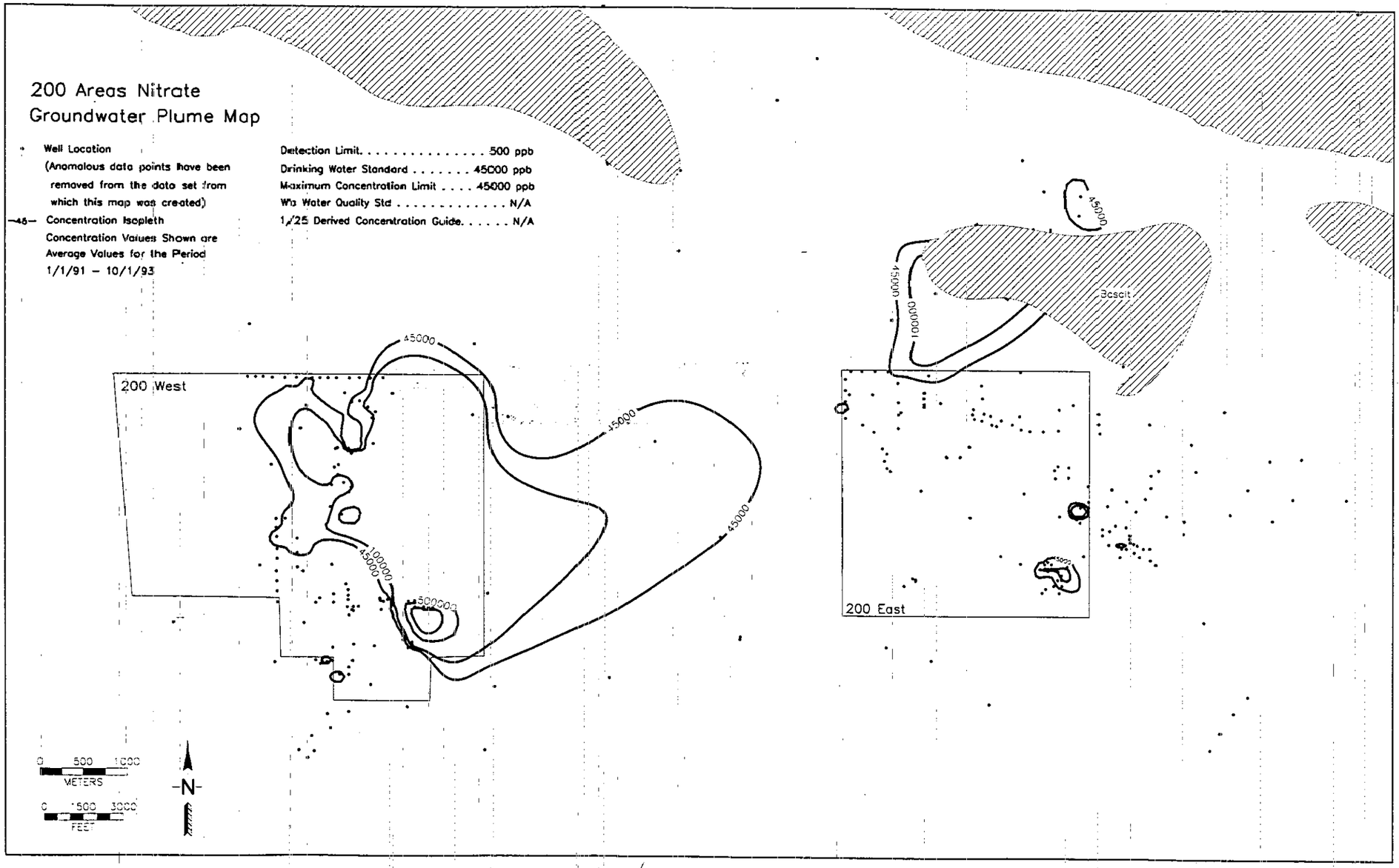

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Figure 4.1-19. Carbon Tetrachloride Distribution in the Uppermost Aquifer Beneath the 200 Area.

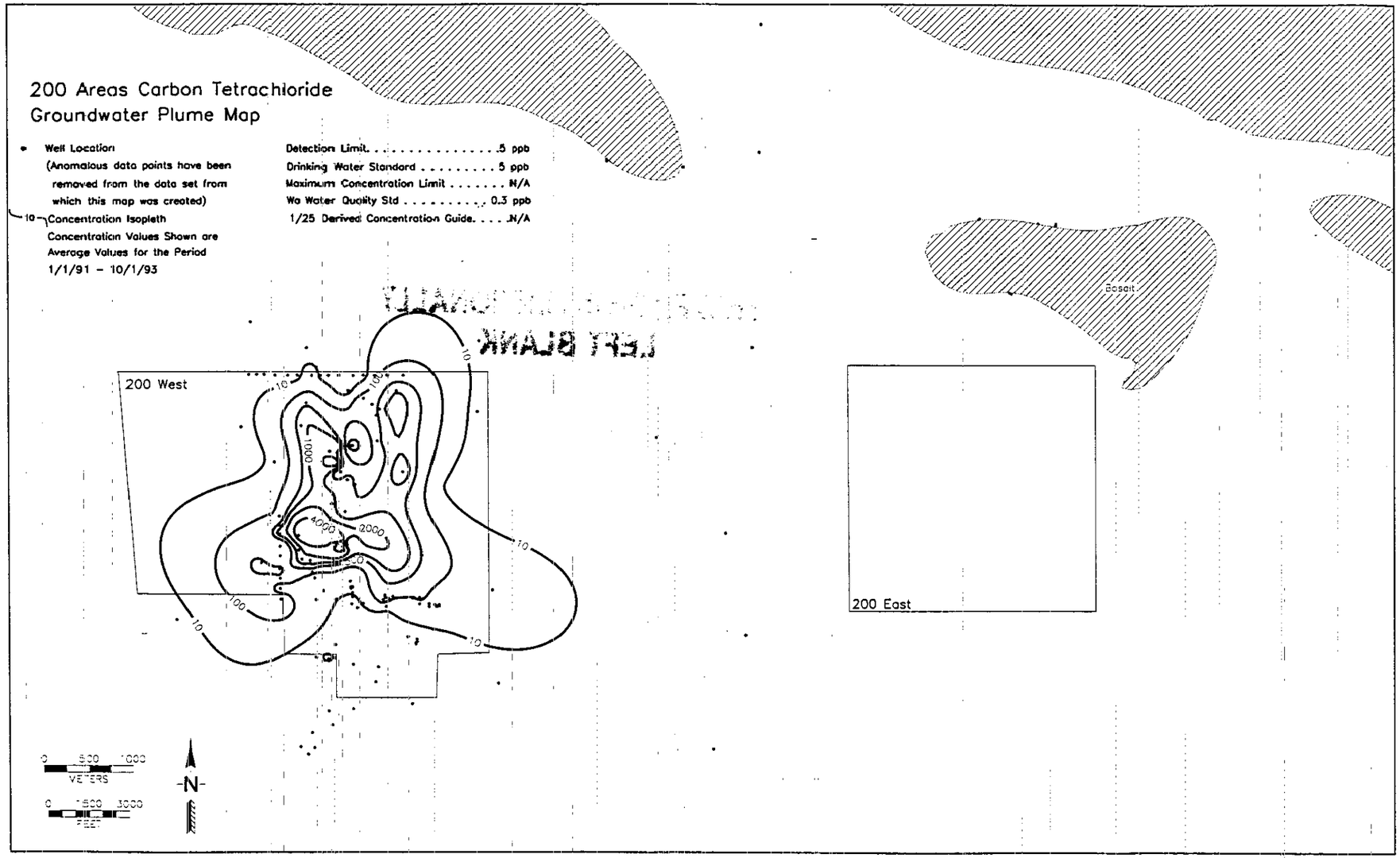

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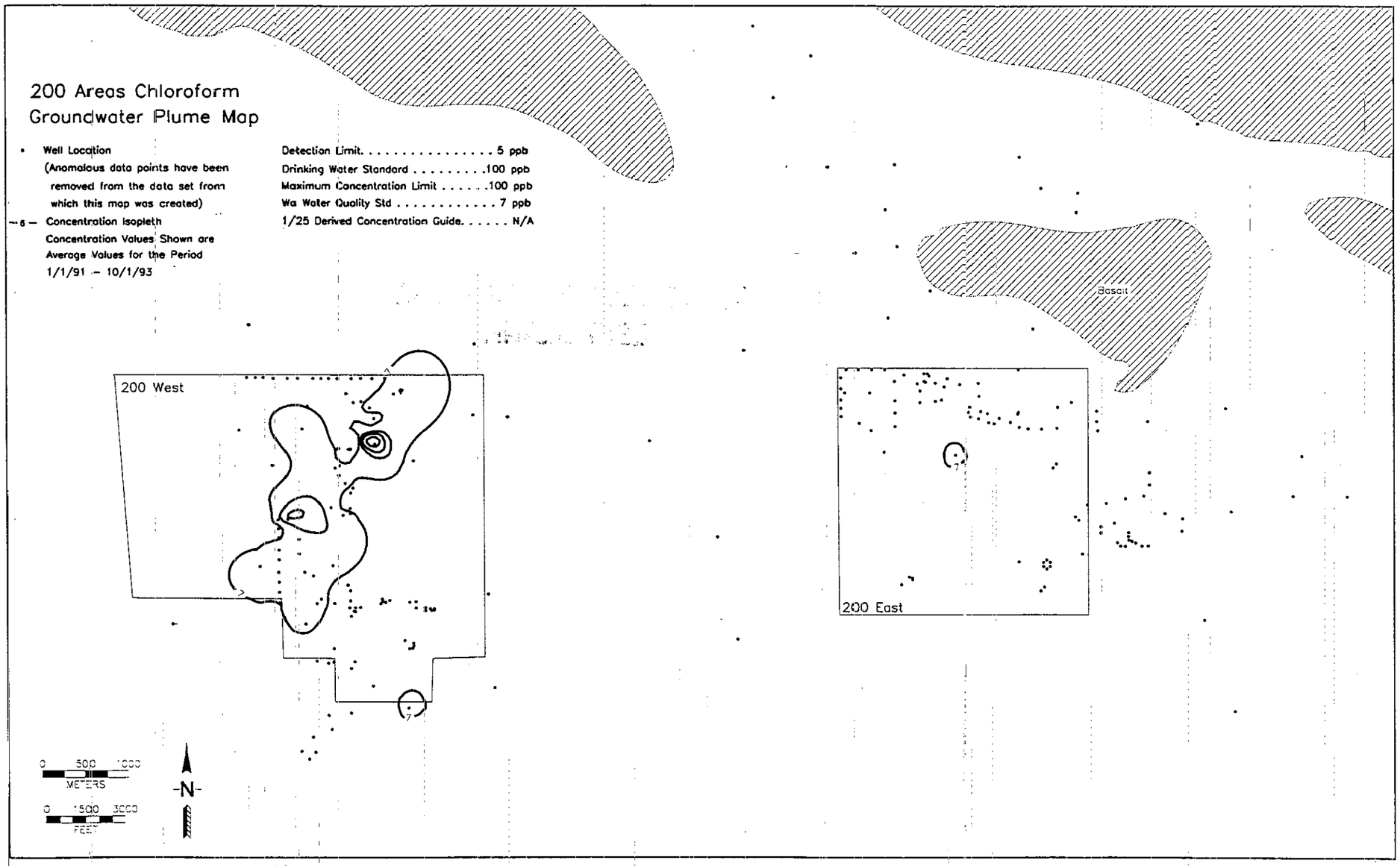
Figure 4.1-20. - Chloroform Distribution in the Uppermost Aquifer Beneath the 200 Area.



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4.1.6.3.3 Trichloroethylene. TCE plumes in the 200 West Area are presented in Figure 4.1-21. The DL for TCE (5 ppb) exceeds the WWQS standard of 3 ppb but is equal to the DWS. The contaminant plumes have been contoured at 6 ppb. Two multiple well plumes are in similar locations but are much less extensive as the northern portions of the chloroform and CCl_4 plumes. The maximum average concentration occurs in well 2-W11-30 (24 ppb). A single-well occurrence is indicated just south of the central portion of the 200 West Area fence line.

4.1.6.4 Tritium. Tritium is discussed separately from the other beta-emitting radionuclides (1) because it is an extremely weak beta emitter and (2) due to its unique chemistry it is the most mobile of the radionuclides and is therefore an excellent contaminant tracer. Tritium contamination (DWS of 20,000 pCi/L extends beneath large portions of the 200 Areas (Figure 4.1-22).

A large plume of contamination originates in the southwest corner of the 200 West Area, extends eastward towards 200 East Area, and may intercept plumes beneath the 200 East Area. There is a lack of well control to define the relationship of the plumes. The maximum average tritium concentration in the plume is in well 699-35-66 (856,750 pCi/L). Another plume beneath the northern half of the 200 West Area has a distribution similar to the volatile organic plume geometries in the vicinity.

Tritium contamination extends diagonally from northwest to southeast beneath the 200 East Area. Highest average concentrations are found in the southeast corner of the area in wells monitoring disposal facilities associated with the PUREX Plant. A discussion of the potential for B Pond to be a hydraulic driver influencing contaminant distribution is presented in the Operational Report for 1990-1992 (WHC 1993b). The highest average concentrations in the plume are found in well 2-E17-20 (2,430,000 pCi/L). A plume of contamination has also moved off to the northwest of the 200 East Area and is indicated by the 20,000-pCi/L contour that appears in the north-central portion of this figure. Additional discussion of this plume is contained in the 100 and 600 Area sections of this report.

4.1.6.5 Beta-emitting radionuclides. The general distribution of beta-emitting radionuclides is presented in Figure 4.1-23. There is a DWS- and WWQS-equivalent standard of 50 pCi/L for gross beta.

Three plumes of contamination beneath 200 West Area are shown in Figure 4.1-23. All three plumes roughly coincide with areas with elevated ^{99}Tc (Figure 4.1-24). The highest average concentrations occur in well 2-W19-20 (2,806 pCi/L) in the plume in the southeastern corner of the 200 West Area. The source of contamination appears to be the U-1 and U-2 Cribs and possibly a transfer line to the U-8 and U-12 Cribs. Three one-well potential plumes of contamination beneath the 200 West Area are also identified.

The largest of the beta plumes in the 200 East Area extends north from the 200 East Area. At least two contaminant sources contributed to the beta contamination, the BY Cribs and Gable Mountain Pond. The highest average concentration in the plume occurs in well 6-50-53A (1,692 pCi/L). This well

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Figure 4.1-21. Trichloroethylene Distribution in the Uppermost Aquifer Beneath the 200 Area.

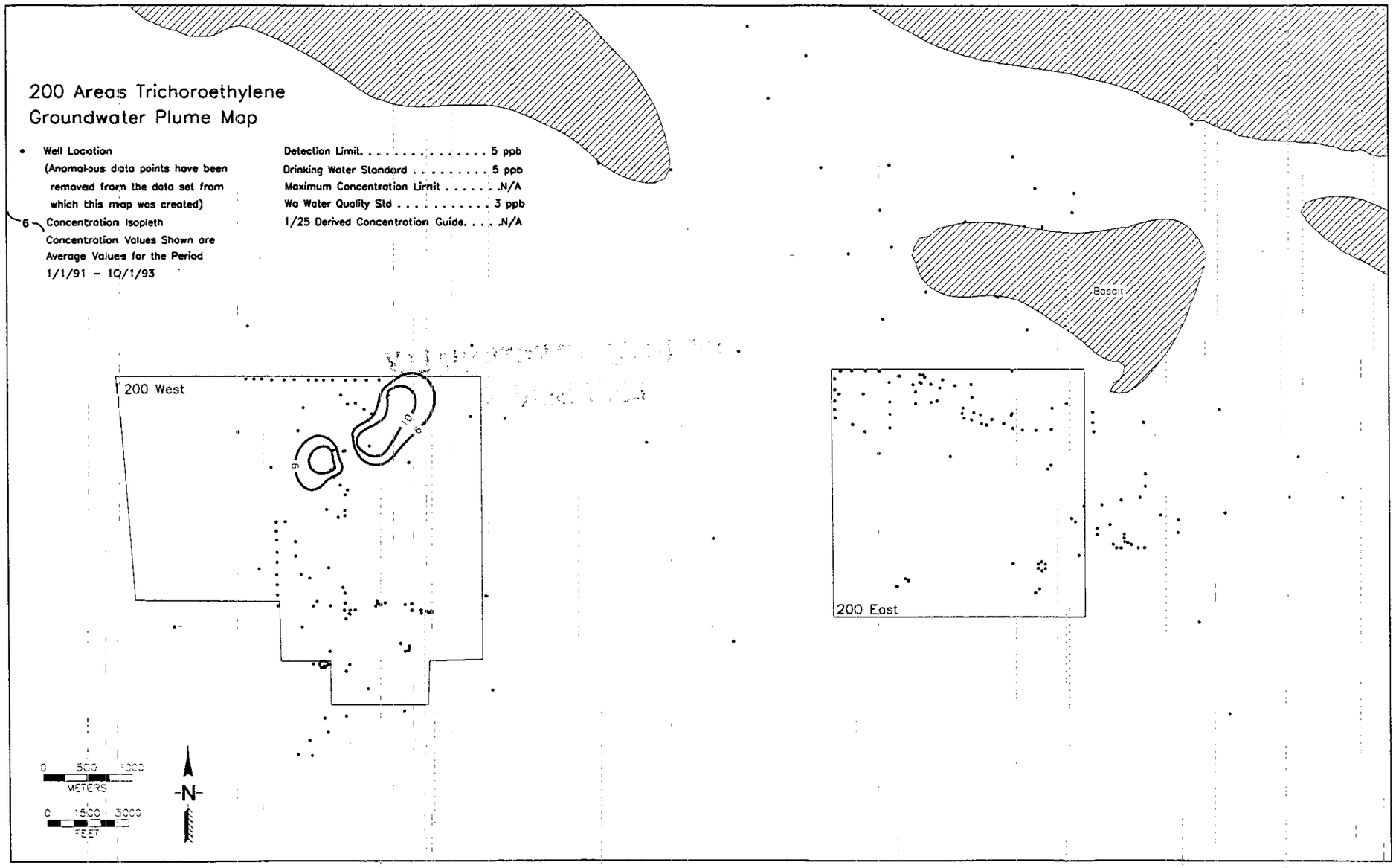

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Figure 4.1-22. - Tritium Distribution in the Uppermost Aquifer Beneath the 200 Area.

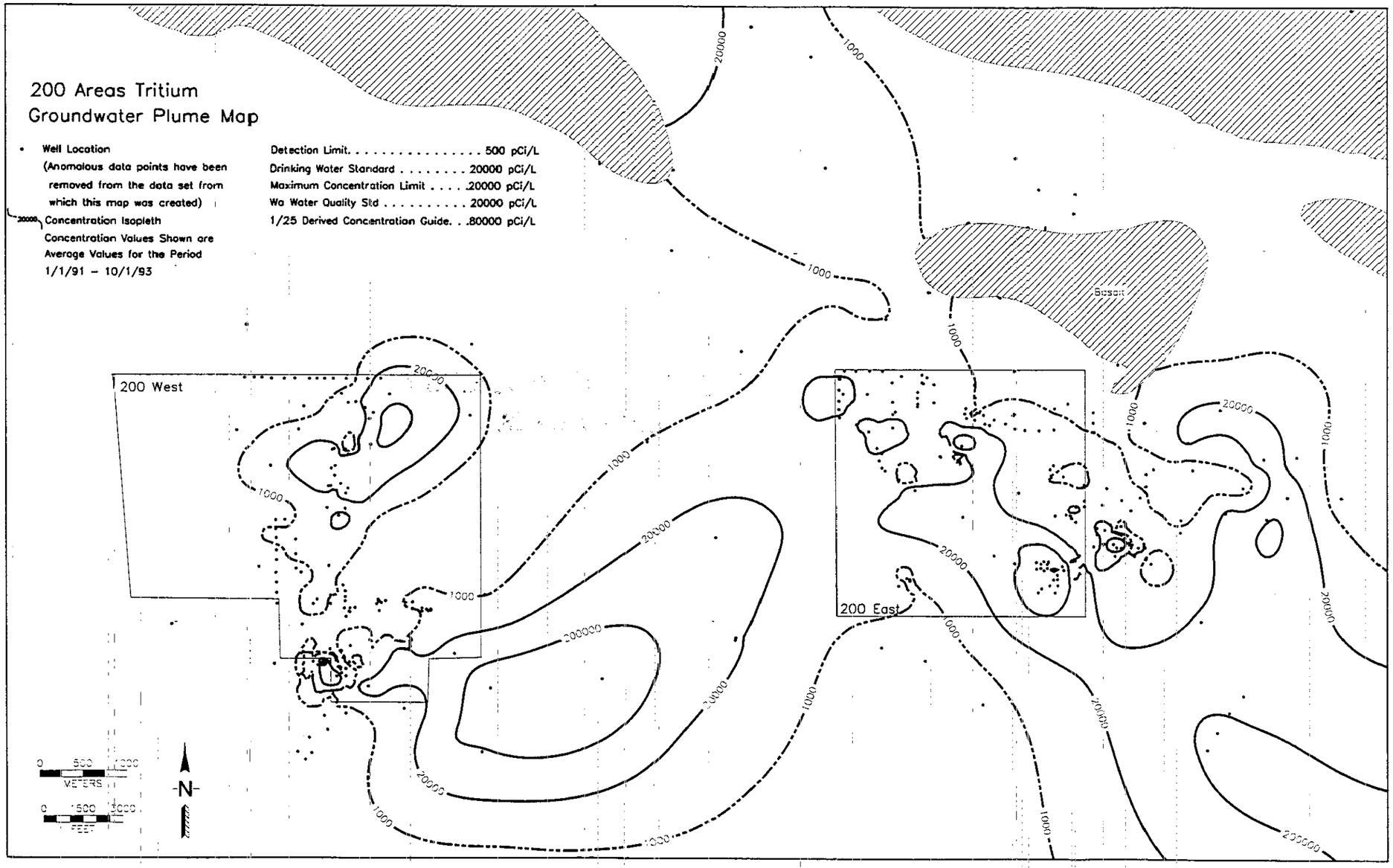

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Figure 4.1-23. Gross Beta Distribution in the Uppermost Aquifer Beneath the 200 Area.

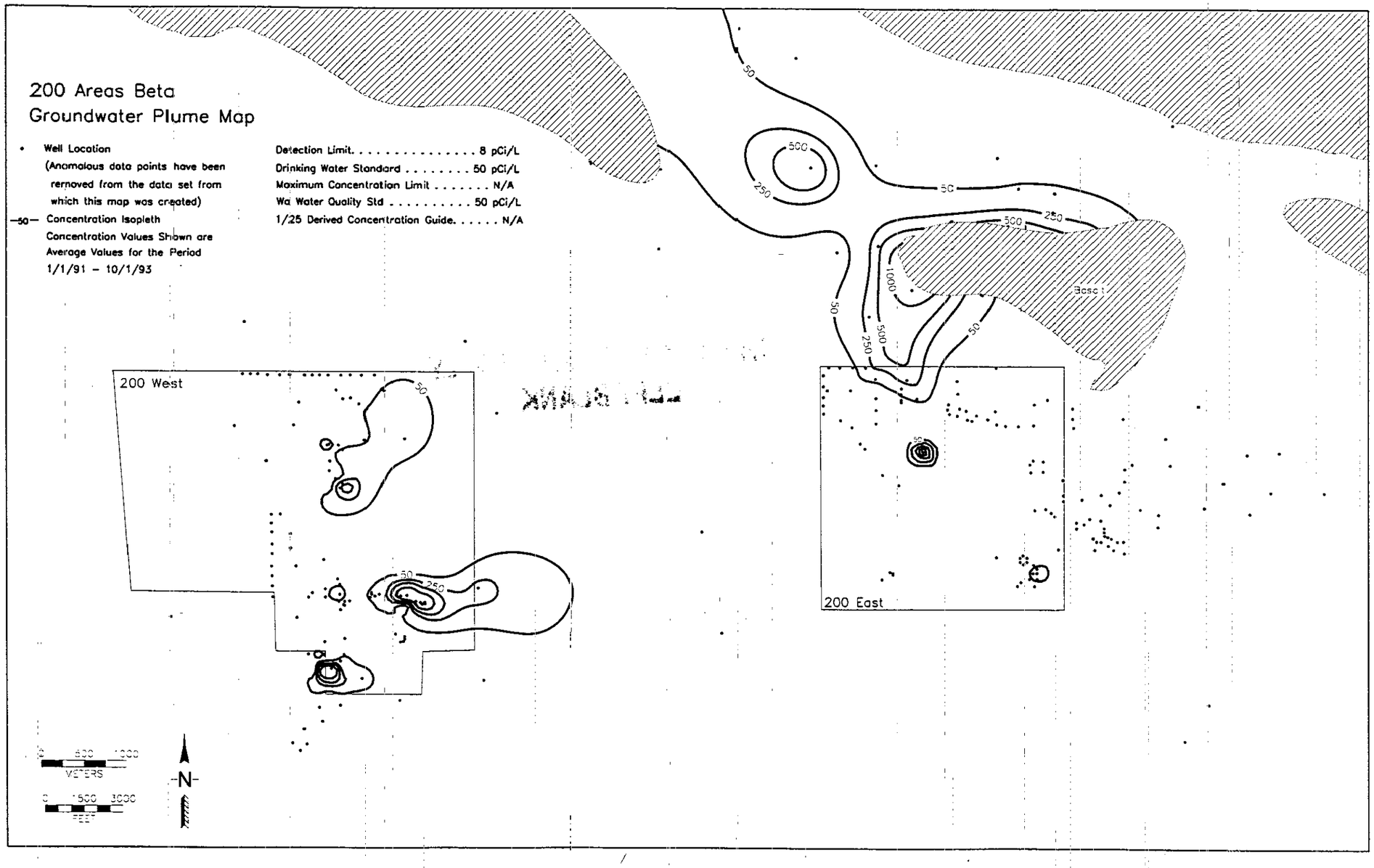

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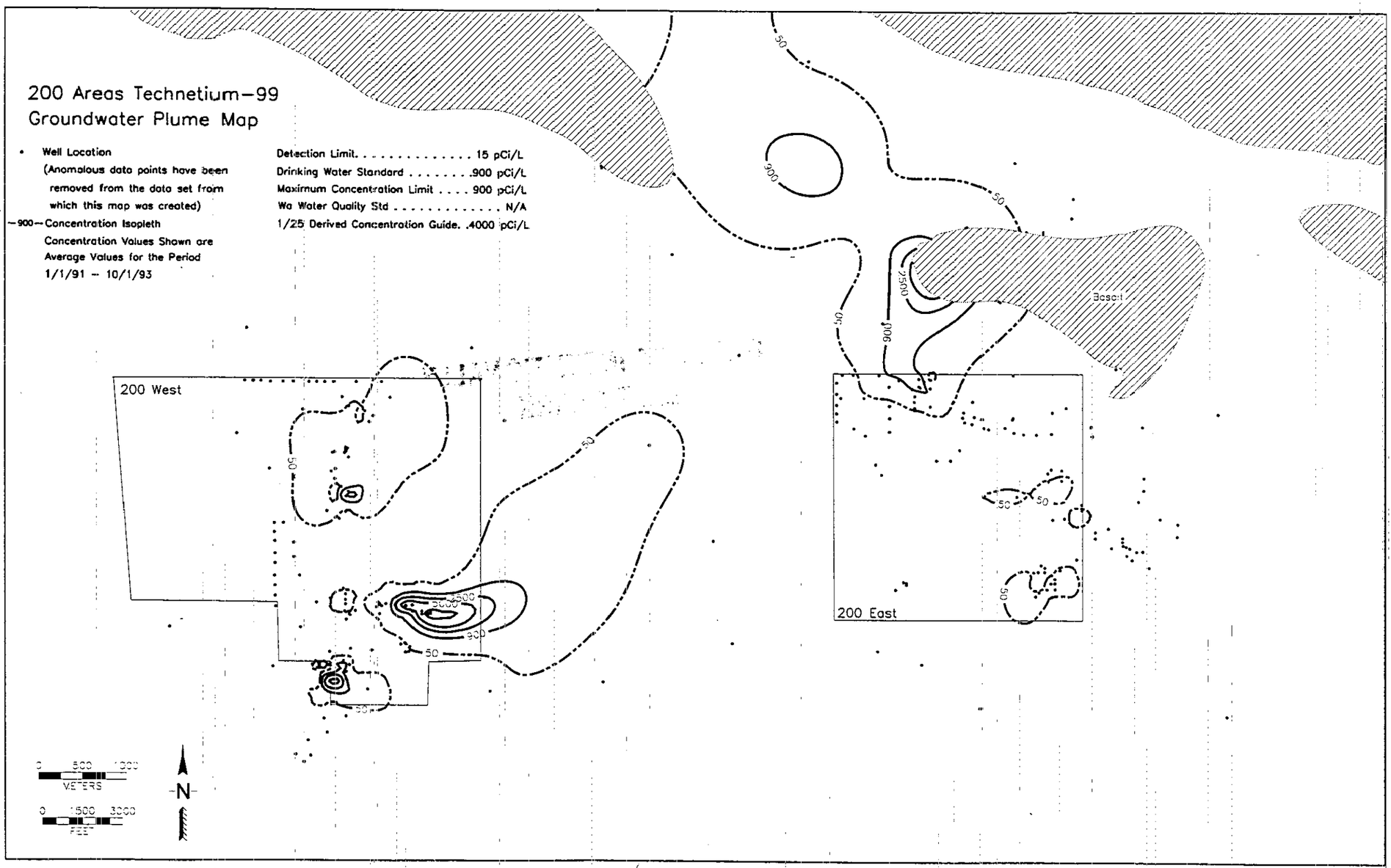
Figure 4.1-24. Technetium-99 Distribution in the Uppermost Aquifer Beneath the 200 Area.



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is the locus for other elevated contaminant concentrations (nitrate and cyanide). Technetium-99, cobalt-60, and strontium-90 are the primary beta emitters contributing to the plume distribution. A tightly constrained beta plume located in the north-central portion of the 200 East Area is associated with contamination in the vicinity of the B-5 reverse well (^{90}Sr and ^{137}Cs). The highest average gross beta concentration in this plume is in well 2-E28-23 (19,500 pCi/L). The final plume beneath the 200 East Area is in the southeast corner in wells that monitor PUREX-related disposal facilities. Technetium-99 and strontium-90 are the primary contributors to beta contamination.

4.1.6.5.1 Technetium-99. The DWS for ^{99}Tc is significantly higher than the MDC (900 versus 15 pCi/L). Three plumes of ^{99}Tc with contamination greater than 900 pCi/L are delineated in Figure 4.1-24 for the 200 West Area. One plume emanates from beneath facilities in the southeast corner of the 200 West Area and has apparently been transported beyond the eastern boundary of the 200 West Area. Maximum average concentrations in excess of 20,000 pCi/L have been detected at the center of the plume (well 2-W19-24). Technetium-99 average concentrations greater than 2,000 pCi/L have been detected in two wells in the south-central portion of the 200 West Area.

In the vicinity of the 200 East Area a plume extending northward from the area is centered on well 699-50-53A (5,198 pCi/L), the same well with the maximum average values for cyanide and ^{60}Co. The plume originates from beneath the BY Crib area along the northern margin of the 200 East Area. A single-well plume to the northwest of the main plume is centered on well 6-55-57. The well also has elevated ^{60}Co.

4.1.6.5.2 Iodine-129. The MDC for ^{129}I is equivalent to the DWS of 1 pCi/L. The minimum isopleth contoured in Figure 4.1-25 is equal to this value.

Two plumes of ^{129}I contamination are present in the groundwater beneath the 200 West Area. One plume appears to have originated from various facilities near the southeastern corner of the 200 West Area and have been transported eastward beyond the boundary of the area. The highest average concentration for the contaminant occurs in well 6-35-70 (37 pCi/L), approximately 549 m (1,800 ft) from the 200 West Area boundary. The other 200 West Area plume is centered on well 299-W14-12 (42 pCi/L) in the north-central portion of the area.

Nearly the entire central portion of 200 East Area is underlain by ^{129}I-contaminated groundwater. The highest average concentrations are found in wells in the southeastern corner of the area, the highest being in well 2-E17-1 (17 pCi/L). The wells monitor PUREX disposal facilities. Another plume extends out of the mapped area to the southeast and is large and very poorly constrained. It vaguely mimics the tritium contaminant plume that extends southeasterly from the 200 East Area and out of the mapped area. The highest average value in this plume is 6 pCi/L.

4.1.6.6 Alpha-emitting radionuclides. Gross alpha contamination in the 200 Areas is shown in Figure 4.1-26. The DWS and WWQS for gross alpha is 15 pCi/L. The two alpha-emitting radionuclides that are responsible for the contamination are uranium and plutonium.

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Figure 4.1-25.- Iodine-129 Distribution in the Uppermost Aquifer Beneath the 200 Area.

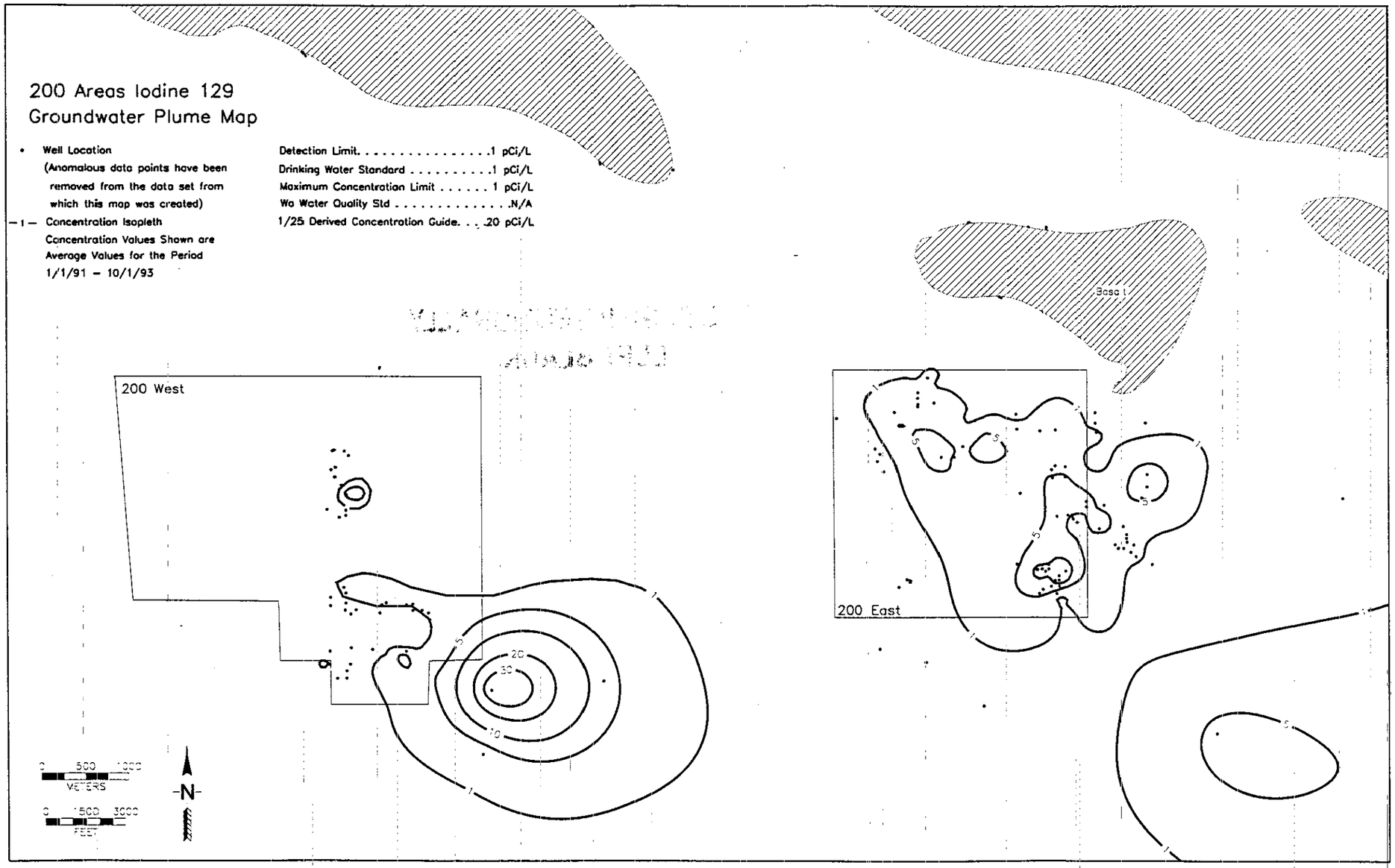

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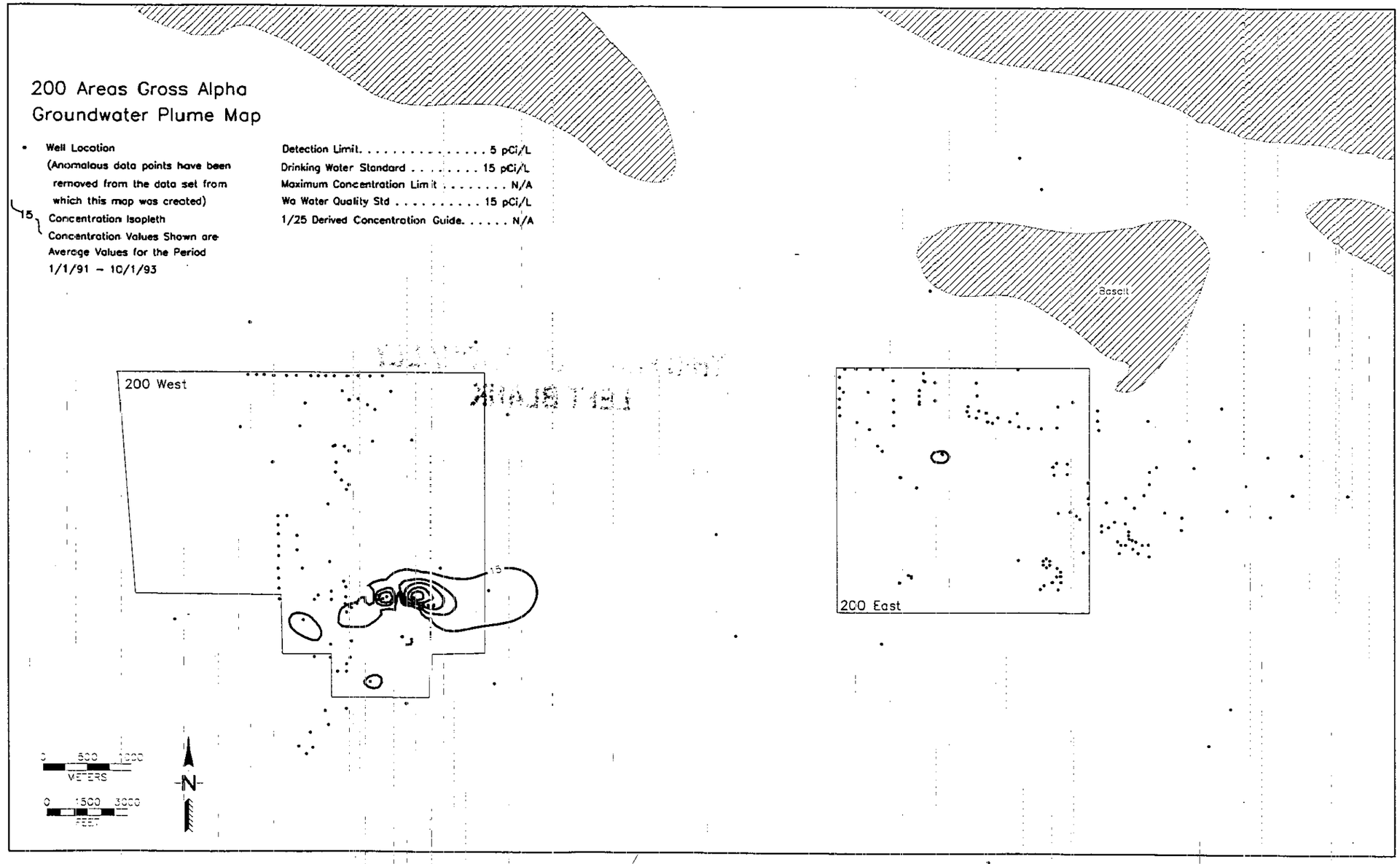
Figure 4.1-26.- Gross Alpha Distribution in the Uppermost Aquifer Beneath the 200 Area.



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Two plumes and one one-well potential plume of alpha contamination are present beneath the 200 West Area. The plumes coincide with mapped uranium contamination. The largest plume has migrated beyond the eastern boundary of the area. Maximum average concentration within the plume exceeds 1,616 pCi/L. Alpha contamination in the plume is connected with mobilization of uranium beneath the 216-U-1 and 216-U-2 Cribs, and possibly leakage from an effluent transfer line to the 216-U-8 and 216-U-12 Cribs. The plume just to the west has the next highest average contamination (207 pCi/L, well 299-W11-14) and appears to be remnant contamination from the 216-U-10 Pond.

A single plume is identified beneath the boundaries to the 200 East Area. Plutonium contamination beneath the B5 reverse well is the alpha-emitting radionuclide responsible for the plume. The highest average contamination is in well 299-E28-25 (43 pCi/L).

4.1.7 References

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4.2 216-S-10 POND AND DITCH

J. W. Lindberg
Westinghouse Hanford Company

4.2.1 Facility Overview

A *Resource Conservation and Recovery Act of 1976* (RCRA) groundwater monitoring network has been established according to the RCRA Interim-Status Groundwater Monitoring Plan (WHC 1990) for the 216-S-10 Pond and Ditch (referred to as the S-10 Facility). This facility operates under RCRA interim-status regulations (40 *Code of Federal Regulations* [CFR] 265). The site is currently in the indicator parameter evaluation program. The site is also within the 200-UP-1 operable unit of the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980.*

The S-10 Facility received wastewater from the Reduction-Oxidation (REDOX) Plant (202-S Building) located in the 200 West Area. This wastewater contained dangerous waste and radioactive materials. From 1985 to October 1991, physical controls and operating procedures were modified to avoid inadvertent discharge of hazardous chemicals to the wastewater stream. Because the S-10 Facility is not expected to receive additional dangerous substances, the U.S. Department of Energy (DOE), Richland Operations Office (RL) has proposed that the facility be closed under RCRA interim-status regulations (40 CFR 265). The effluent stream to the S-10 Facility was permanently deactivated in October 1991.

The S-10 Facility is located south-southwest of the 200 West Area, directly outside the perimeter fence (see Figure 4.1-1, Section 4.1). Initially the S-10 Facility consisted of an open, unlined ditch that was 1.82 m (6 ft) deep, 1.21 m (4 ft) wide at the bottom, and 685.8 m (2,250 ft) long. Additionally, an open, unlined percolation pond, constructed at the southwest end of the 216-S-10 Ditch and approximately 2.0 ha (5 acres) in size, was active during part of the time that the ditch was receiving waste.

The 216-S-10 Ditch began receiving wastewater from the REDOX Plant in August 1951. The 216-S-10 Pond was dug and placed in service in February 1954. In October 1985, the 216-S-10 Pond and portions of the 216-S-10 Ditch were decommissioned, backfilled, and stabilized. The remaining portion of the 216-S-10 Ditch received nondangerous, nonregulated wastes from the 202-S Building chemical sewer. The waste stream was composed of cooling water, steam condensate, water tower overflow, and drain effluent. Releases of dangerous materials and constituents to the S-10 Facility are poorly documented. Radioactive waste was reportedly disposed of to the S-10 Facility as a result of contaminated floor and sewer drains at the REDOX Plant. Hazardous chemical releases were documented in 1954 and 1983 and included $Al(NO_3)_3$, $NaNO_3$, NaOH, Na_3PO_4, NaF, NaCl, and $K_2Cr_2O_7$. There has been no effluent discharge to the facility since October 1991.

The volume of effluent discharged in 1991 to the 216-S-10 Ditch was approximately 1.89 x 10^8 L (5.0 x 10^7 gal). This discharge previously created a localized recharge mound and an associated perched water table directly below the receiving end of the 216-S-10 Ditch. Well 299-W26-11 was installed in 1990 to monitor the perched aquifer.

Stratigraphy at the S-10 Facility includes about 52 m (171 ft) of Hanford formation consisting of silt and sand, 1.8 m (6 ft) of Plio-Pleistocene unit composed of silty sandy gravel and capped with a 0.3-m (1-ft) layer of caliche, 14 m (45 ft) of upper Ringold unit sand, 60 m (199 ft) of Ringold Formation unit E composed of sandy gravel, and approximately 15 m (50 ft) of the lower mud unit of the Ringold Formation. The top of the lower mud unit is the base of the uppermost aquifer system at the S-10 Facility. Most of the uppermost aquifer is within the approximately 61-m- (200-ft-) thick gravel unit E of the Ringold Formation; however, the water table is approximately 2 m (7 ft) above unit E in the upper Ringold unit. Depth to water varies from 55 m (180 ft) toward the southwestern end of the S-10 Facility and about 67 m (220 ft) toward the northeastern end. Additional information about the general hydrogeology of the 200 Areas can be found in Section 4.1.

Before 1992 the discharge of water at the S-10 Facility caused a perched water zone. Perching occurred on the silt and fine sand within the lower portion of the Hanford formation or possibly the caliche layer at the top of the Plio-Pleistocene unit. Depth to water in the perched zone was about 38 m (125 ft). However, when surface water discharges ceased in 1991, the perched water began receding. The water level within the well installed in this perched zone (299-W26-11) dropped below the level of the well screen shortly after the surface water discharges ceased at the S-10 Facility.

4.2.2 Summary of 1993 Activities

Sampling and analysis were performed for the wells in the monitoring network according to the RCRA Interim-Status Groundwater Monitoring Plan (WHC 1990). The facility now has two upgradient and four downgradient monitoring wells (Figure 4.2-1). This monitoring network will be used to monitor groundwater levels and water quality before and after closure of the ditch. Well 299-W27-2 was the last well to be installed. It monitors the base of the unconfined aquifer and was completed in December 1992.

Four quarters of required background sampling were completed in June 1992. At that time the sampling schedule changed from background monitoring status (quarterly sampling) to the indicator parameters evaluation program with semiannual sampling. A statistical evaluation of the analytical results is presented in Section 4.2.4.2.

4.2.3 Sampling and Analysis Program

The groundwater monitoring plan for the S-10 Facility (WHC 1990) establishes the justification and requirements for the monitoring network. The current monitoring well network consists of six wells as listed in Table 4.2-1 and as shown in Figure 4.2-1. Five monitor the upper portion of

Figure 4.2-1. Monitoring Well Locations for the 216-S-10 Facility.

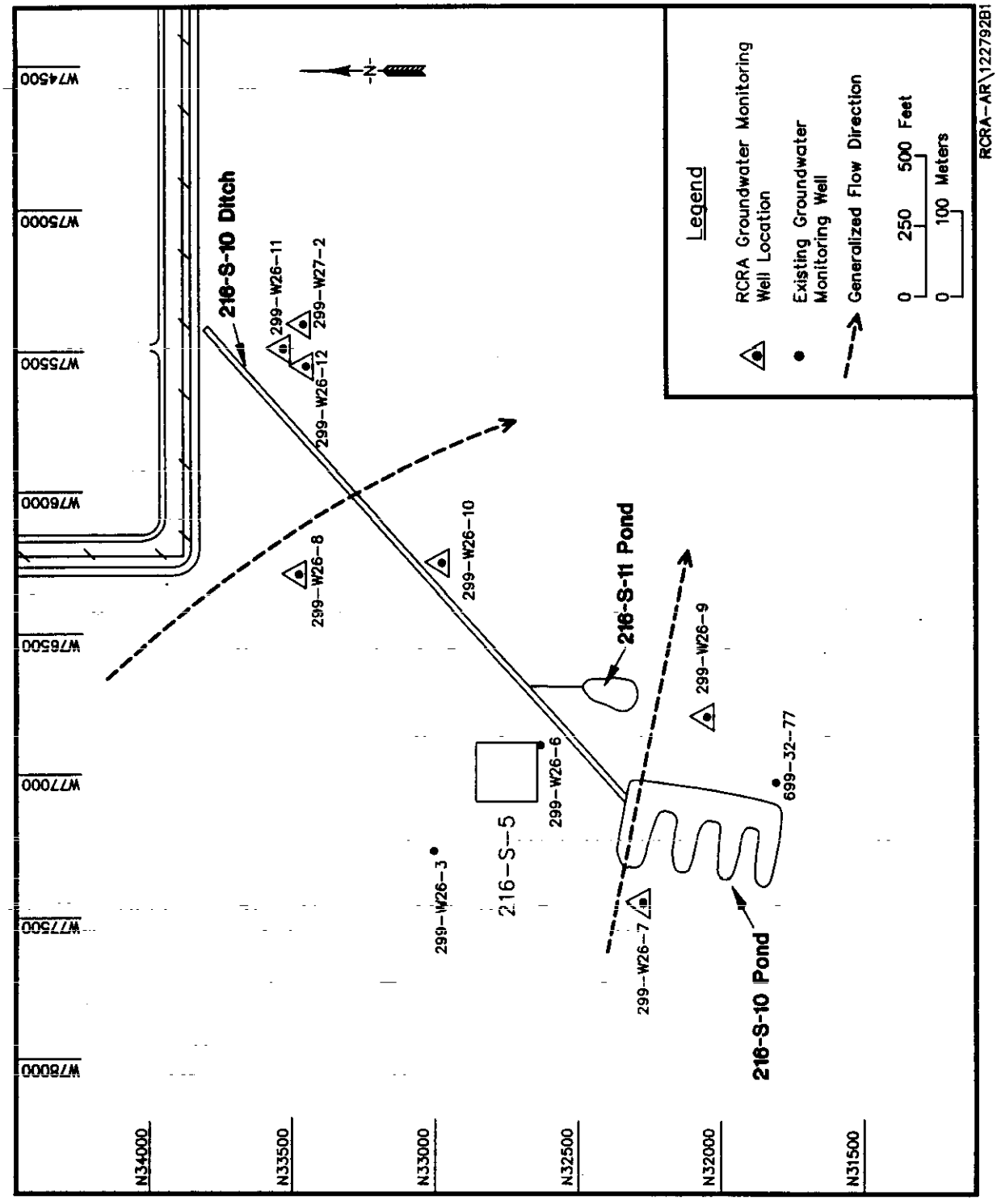


Table 4.2-1. 216-S-10 Facility Groundwater Monitoring Network.

Well	Aquifer	Sampling frequency	Water levels	Well standards
299-W26-7[91]	Top of unconfined	S	S	RCRA
299-W26-8[90]	Top of unconfined	S	S	RCRA
299-W26-9[90]	Top of unconfined	S	S	RCRA
299-W26-10[91]	Top of unconfined	S	S	RCRA
299-W26-12[91]	Top of unconfined	S	S	RCRA
299-W26-11[90]	Perched zone	NS	NS	RCRA
299-W27-2[92]	Base of unconfined	Q	Q	RCRA

Notes: Shading denotes upgradient wells. Superscript following well number denotes the year of installation.
NS = not sampled; dropped from monitoring network. (Dry well, see Sections 4.2.1 and 4.2.3.)
Q = frequency on a quarterly basis.
RCRA = well is constructed to RCRA-specified standards.
S = frequency on a semiannual basis.

the unconfined aquifer, and one (299-W27-2) monitors the base of the unconfined aquifer. The perched aquifer monitoring well (299-W26-11) was dropped from the monitoring network because it has not contained any water since the effluent stream was deactivated in October 1991. Before well 299-W26-11 is recommended for decommissioning, it is being evaluated to determine whether there are other uses for the well. The other wells in the monitoring network were sampled for contamination indicator parameters, drinking water standards (DWS) (40 CFR 265, Appendix III), groundwater quality parameters, and site-specific parameters as identified in Table 4.2-2. Site-specific parameters were selected based on a history of waste disposed at this site and in surrounding cribs.

4.2.4 Groundwater Chemistry

A brief discussion of the analytical data available for 1993 is provided below. Tables summarizing the available analytical data for the year can be found in the RCRA quarterly reports (Teel 1993a, 1993b, 1993c; Lindberg 1994).

4.2.4.1 Constituents of Concern. During 1993, constituents detected above the DWSs consisted of chromium (filtered and unfiltered), manganese (filtered and unfiltered), unfiltered iron, pH, and turbidity. Elevated unfiltered metals like chromium, manganese, and iron are thought to have been introduced during well construction or may be related to turbidity (see Section 2.2.4). Standards for turbidity do not apply to groundwater and are measured only as an indicator of the condition of the well and representativeness of the groundwater samples.

Table 4.2-2. Constituents Analyzed at the 216-S-10 Facility.

Contamination indicator parameters		
pH	Total organic carbon	
Specific conductance	Total organic halogen	
Groundwater quality parameters		
Chloride	Manganese	Sodium
Iron	Phenols	Sulfate
Drinking water parameters		
2,4-D	Endrin	Methoxychlor
2,4,5-TP Silvex	Fluoride	Nitrate
Arsenic	Gross alpha	Radium
Barium	Gross beta	Selenium
Cadmium	Lead	Silver
Chromium	Lindane	Toxaphene
Coliform bacteria	Mercury	Turbidity
Site-specific parameters		
Technetium-99	Uranium	
Tritium	Volatile organic analysis	

Filtered chromium concentrations above the DWS occurred in upgradient well 299-W26-7, which is located at the south end of the facility near the 216-S-10 Pond. The elevated values for this well were 200 ppb (3/15/93) and 210 ppb (6/28/93); the DWS is 100 ppb. Well 299-W26-7 has shown elevated chromium values both in the filtered as well as unfiltered since its construction. The elevated chromium concentration in this well is isolated from the known chromium plume to the northeast, and it is not found in other upgradient and downgradient wells in the vicinity. Because the well is upgradient of the S-10 Facility, it is doubtful the contaminant came from the facility. Possible causes include well construction effects or the presence of colloidal-size particles that cannot be effectively filtered.

Filtered manganese concentrations above the DWS occurred in downgradient well 299-W27-2, which monitors the lower part of the unconfined aquifer. The elevated values for this well were 130 ppb (12/22/92) and 72 ppb (3/18/93). The DWS is 50 ppb. Unfiltered manganese results have been high in this well and in other surrounding wells. Like chromium and iron, this contaminant may be due to well construction. In the case of well 299-W27-2, the elevated values of manganese could be related to greater turbidity. However, because filtered manganese has not been a problem previously, the source is unknown. This contaminant will be monitored closely in succeeding samples to see if the values continue to remain high.

A groundwater sample collected on June 28, 1993 from the upgradient well 299-W26-8 had a pH that slightly exceeded the DWS of 8.5 by approximately 0.2. Like manganese in well 299-W27-2, the pH in well 299-W26-8 will be closely monitored in succeeding months.

Site-specific parameters monitored during the reporting period consisted of volatile organic compounds, tritium, ^{99}Tc, and uranium. Volatile organic compounds, tritium, and ^{99}Tc were not detected. A plot of uranium concentrations is shown in Figure 4.2-2. This figure shows that upgradient well 299-W26-8 has consistently higher uranium concentrations than the other wells in the network. The elevated uranium concentrations may be from the area of the 216-U-10 Pond, which is known to have received radioactive wastewater (DOE-RL 1992). Further evidence that the elevated uranium values are from an upgradient source is the gross alpha plume that extends to well 299-W26-8 (see Figure 4.1-26, Section 4.1).

4.2.4.2 Statistical Evaluation. Statistical evaluations of data for the past year at the S-10 Facility consisted of the required comparisons of indicator parameters between upgradient and downgradient wells for any indication of contamination in the groundwater underlying the facility. Statistical methods are described in Appendix C. The contamination indicator parameters for the S-10 Facility include field specific conductance, field pH, total organic carbon (TOC), and total organic halogen (TOX). Statistical analyses required by 40 CFR 265.93(b) and *Washington Administrative Code* (WAC) 173-303-400 were performed on the samples collected from August 1991 to June 1992 for upgradient wells 299-W26-7 and 299-W26-8. Results are presented in Table 4.2-3. This table lists the background average, background standard deviation, and critical mean (or critical range, in the case of pH) for the four contamination indicator parameters from the upgradient well (or wells). The critical mean (or critical range) is the value to which future averages of quadruplicate measurements are compared. During the past year, none of the upgradient/downgradient comparison values were exceeded at the S-10 Facility.

The upgradient/downgradient comparison value is generally the critical mean or critical range. However, the critical mean for TOC is not calculated because all of the background values taken from the upgradient wells for TOC are less than the contractually required quantitation limit. In this case, the quantitation limit is used as the comparison value for TOC (see Appendix C).

If the average from a downgradient well for a parameter exceeds the upgradient/downgradient comparison values listed in Table 4.2-3, that parameter is considered statistically different from background. If this is confirmed by subsequent verification sampling and analysis, the regulatory program is triggered into assessment. None of the samples collected during the last year for the upper portion of the unconfined aquifer had indicator parameters that exceeded the critical means (or in the case of pH, critical range). The TOX critical mean is not calculated because of unsatisfactory audit findings (see Appendix A). However, field specific conductance for well 299-W27-2 ranged from 348 to 366 μmho/cm. The critical mean for field-specific conductance is 301.1 μmho/cm. Although the groundwater samples from well 299-W27-2 exceed the critical mean for field-specific conductance, it is inappropriate to compare these analytical results with the critical mean

Figure 4.2-2. Uranium Concentration Plot for the 216-S-10 Facility Monitoring Wells.

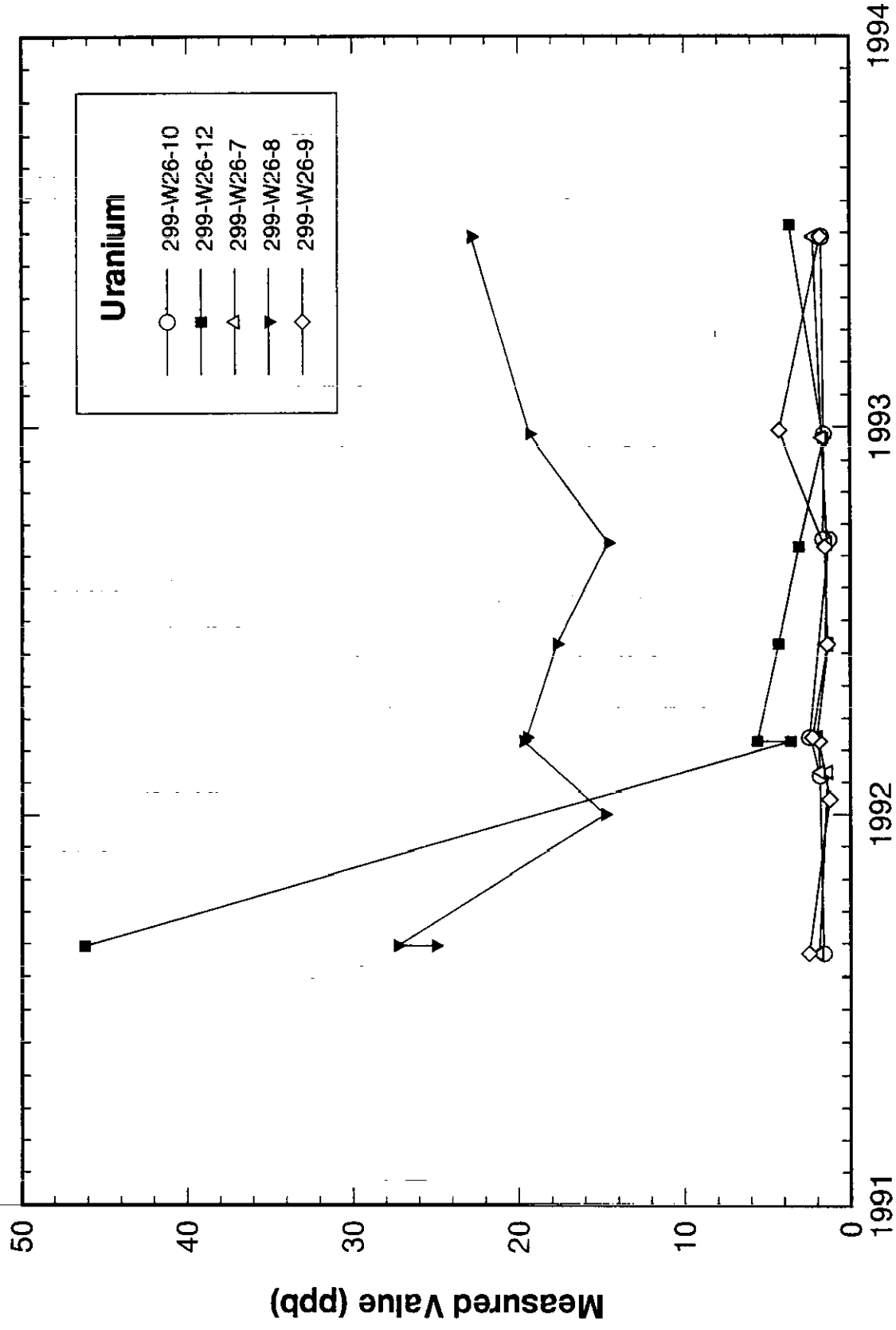


Table 4.2-3. Critical Means Table for 20 Comparisons--Background Contamination Indicator Parameter Data for the 216-S-10 Facility.[a,b]

Constituent (unit)	n	df	t_c	Average background	Standard deviation	Critical mean	Upgradient/ downgradient comparison value
Specific conductance (μmho/cm)	8	7	5.4079	248.375	9.186	301.1	301.1
Field pH	8	7	6.0818	7.888	0.178	[6.74, 9.04]	[6.74, 9.04]
Total organic carbon[c] (ppb)	7[e]	6	5.9588	500	NC	NC	800[f]
Total organic halogen[d] (ppb)	NC	NC	NC	NC	NC	NC	NC

[a]Data collected from August 1991 to June 1992 for upgradient wells 2-W26-7 and 2-W26-8. Values calculated based on 20 comparisons.

[b]The following notations are used in this table:
df = degrees of freedom (n-1)
n = number of background replicate averages
t_c = Bonferroni critical t-value for appropriate df and 20 comparisons.

[c]Critical mean cannot be calculated because of lack of an estimate of background standard deviation.

[d]Critical mean cannot be calculated because of problems associated with data quality.

[e]Excluding total organic carbon values collected on 2/11/92 from well 2-W26-7 because of Nonconformance Report.

[f]Upgradient/downgradient comparison value for total organic carbon is the limit of quantitation based on 1993 field blanks data (see Appendix A).

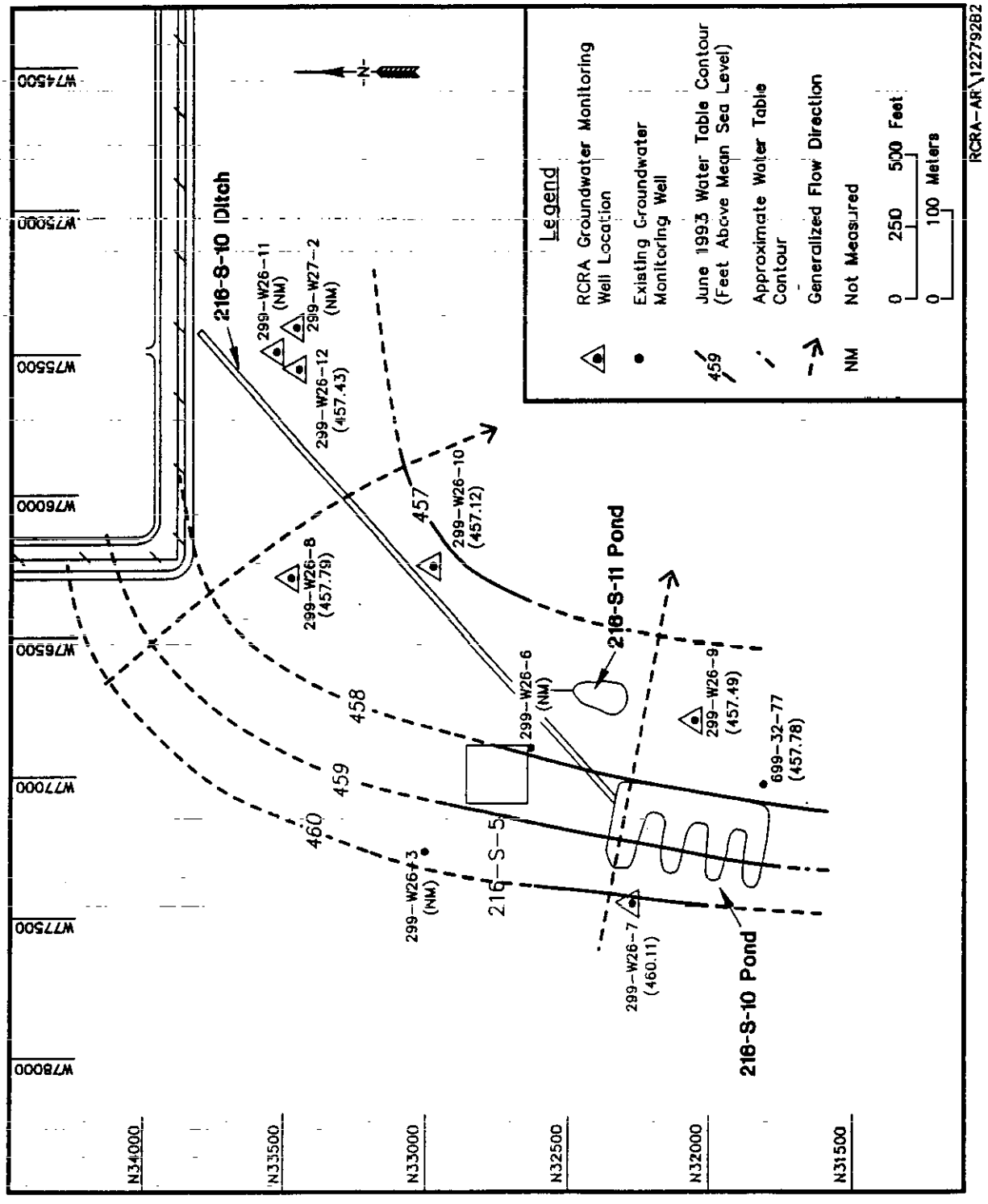
NC = not calculated.

because well 299-W27-2 samples the bottom of the unconfined aquifer. The critical means were calculated from samples and analytical results corresponding to the upgradient wells (299-W26-7 and 299-W26-8) that sample groundwater in the upper portion of the unconfined aquifer.

4.2.5 Groundwater Flow

4.2.5.1 Groundwater Flow Direction. Tables summarizing available water level data are reported in the previous RCRA quarterly reports (Teel 1993a, 1993b, 1993c; Lindberg 1994). Figure 4.2-3 depicts the contoured water table

Figure 4.2-3. 216-S-10 Facility Water Table Map, June 1993.



elevations for the unconfined aquifer for June 1993. This figure indicates that the flow direction is toward the east to southeast beneath the S-10 Facility. This general flow direction coincides with the regional groundwater map (see Figure 4.1-13, Section 4.1). Well hydrographs (Figure 4.2-4) show the continued declines in water table elevations with time at the S-10 Facility.

4.2.5.2 Rate of Flow. The rate of groundwater flow can be estimated by using a form of the Darcy equation with a range of input parameters.

$$v = \frac{Ki}{n_e} \quad (1)$$

where:

v = Average linear velocity of groundwater
K = Horizontal hydraulic conductivity
i = Hydraulic gradient
n_e = Effective porosity of the aquifer.

The following input parameters were used:

K = 10 m/d (34 ft/d) (Williams and Barnett 1993); 12 to 152 m/d (40 to 500 ft/d) (Kipp and Mudd 1973)
i = 0.0059 to 0.0013 (June 1993)
n_e = 0.1 to 0.3.

Resulting estimates of groundwater velocity range from 0.04 to 9 m/d (0.15 to 29.5 ft/d).

The most recent aquifer testing in network wells was done in November 1992 when a constant discharge test was performed (at the water table in well 299-W27-2) with an observation well (299-W26-12) (Williams and Barnett 1993). The interpreted hydraulic conductivity is 10 m/d (34 ft/d) from the measured transmissivity. Slug tests in the same well provided similar results (6 to 10 m/d [21 to 34 ft/d] hydraulic conductivity). These results have a much smaller range than the results reported by Kipp and Mudd (1973) (12 to 152 m/d [40 to 500 ft/d]). If only the more recent estimates of hydraulic conductivity are used, the resulting estimates of groundwater velocity would fall more closely to the lower end of the originally estimated range (0.04 to 0.6 m/d [0.15 to 2.0 ft/d]).

4.2.5.3 Evaluation of Monitoring Well Network. Based on the MEMO model (Jackson et al. 1991) and the hydrogeology of the site, the existing network should provide a monitoring efficiency of approximately 85% for the S-10 Facility. Therefore, the network is judged to be adequate for the indicator parameter evaluation program. There are no plans to drill additional wells nor to modify the existing ones unless future groundwater sampling results indicate a significant change in groundwater chemistry, or there is a significant change in groundwater flow conditions.

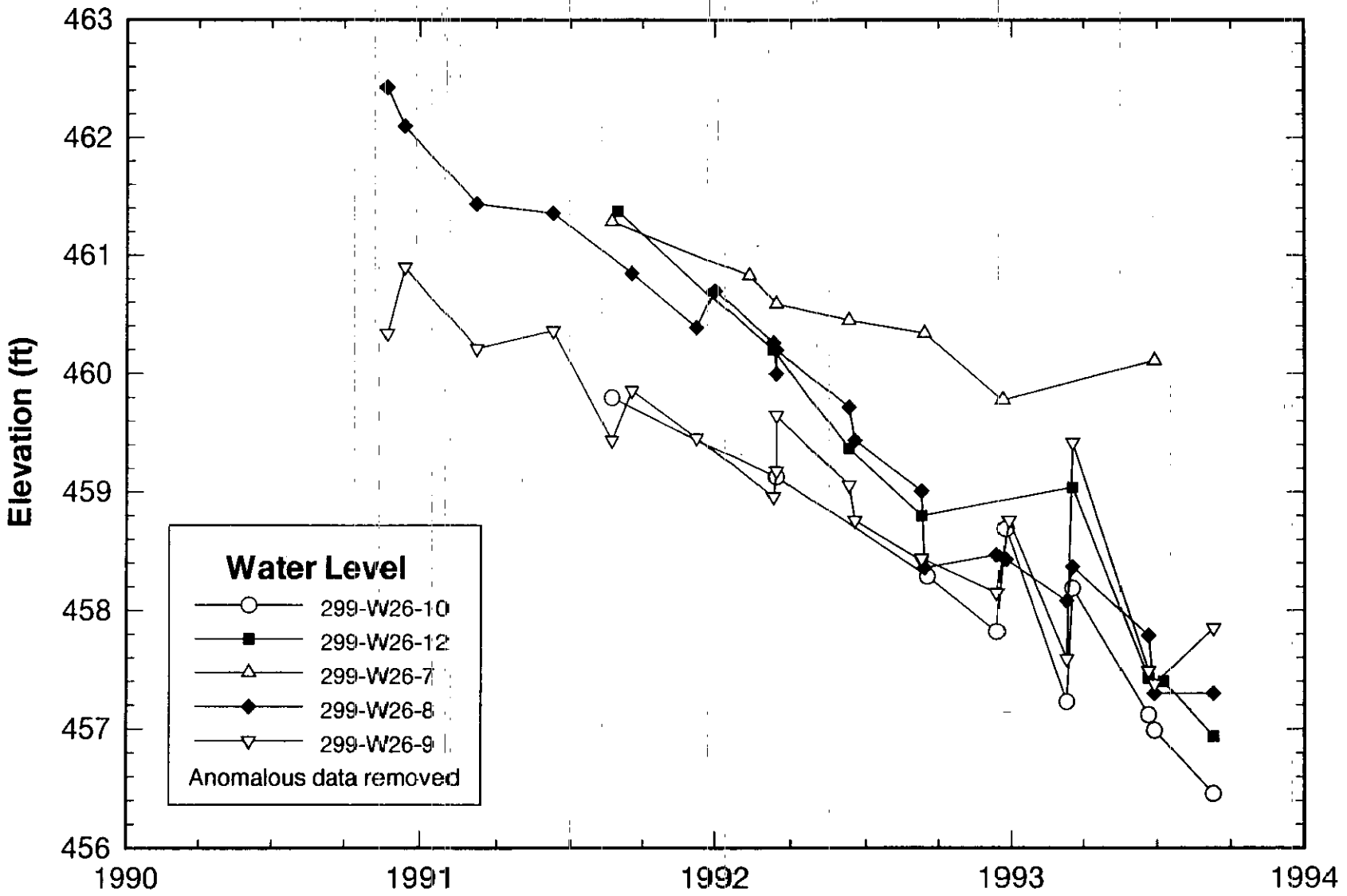


Figure 4.2-4. Hydrograph of the 216-S-10 Facility Unconfined Aquifer Monitoring Wells.

4.2.6 References

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4.3 216-U-12 CRIB

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4.3.1 Introduction

A *Resource Conservation and Recovery Act of 1976* (RCRA) assessment-level groundwater monitoring program has been established under guidelines in the RCRA interim-status groundwater monitoring plan (WHC 1990) for the 216-U-12 Crib (referred to as the U-12 Crib). This plan was developed to present a program to determine the impact, if any, of the U-12 Crib on the quality of groundwater underlying the facility. The U-12 Crib received wastewater from the U Plant in the 200 West Area from April 1960 until February 1988, when the crib was permanently retired and replaced by the 216-U-17 Crib. The wastewater disposed to the U-12 Crib contained dangerous waste and radioactive materials.

An indicator evaluation groundwater monitoring network, consisting of one upgradient (299-W22-43) and three downgradient wells (299-W22-40, 299-W22-41, and 299-W22-42), was installed in early 1990 and is operated under RCRA interim-status regulations (40 *Code of Federal Regulations* [CFR] 265). Initial background groundwater sampling under RCRA began in September 1991. Background values of the indicator parameters were established after the June 1992 sampling event and are reported in DOE-RL (1993a). The statistical analysis required by 40 CFR 265.93(b) was completed using September 1992 sample data (DOE-RL 1993b). These and subsequent sampling results revealed that the contamination indicator parameter specific conductance in downgradient wells 299-W22-41 and 299-W22-42 is statistically greater than the background levels of this parameter. As required in 40 CFR 265.93(d)(2), the *Interim-Status Ground-Water Quality Assessment Plan for the 216-U-12 Crib* (WHC 1993) was completed and released. This plan develops a groundwater quality assessment program to determine if contaminants in the referenced wells originate in the U-12 Crib.

4.3.1.1 Overview of the Facility. The U-12 Crib is located approximately 610 m (2,000 ft) south of the U Plant in the 200 West Area (see Figure 4.1-1, Section 4.1). The U-12 Crib is within the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) 200-UP-1 groundwater operable unit. The U-12 Crib is an unlined, gravel-bottom, percolation crib that is 3.05 m (10 ft) wide, 30.5 m (100 ft) long, and 4.3 m (14 ft) deep. The U-12 Crib has a plastic barrier cover and is backfilled with the original excavated soil. A vitrified clay distributor pipe buried in gravel dispersed the effluent across the bottom of the U-12 Crib.

The waste was composed of effluent from the U Plant and included 291-U-1 Stack drainage and process condensate from the 224-U Building. The U-12 Crib received this waste stream from April 1960 until 1972, when it was deactivated. The U-12 Crib was reactivated in November 1981, and received waste until it was permanently retired in February 1988. An average of over 1.33×10^8 L/yr (3.5×10^7 gal/yr) of effluent was disposed to the U-12 Crib during its active life. The U-12 Crib has received low-level radioactive

waste that is known to have included dilute nitric acid, as well as radioactive waste containing plutonium, strontium, ruthenium, and uranium. After 1985, physical controls and operating procedures were modified to avoid inadvertent discharge of hazardous chemicals to the wastewater stream.

Hydrogeologic investigations below the U-12 Crib have indicated radioactive contamination to a depth of at least 42.7 m (140 ft) as of 1983, and to a depth of 19.5 m (64.5 ft) during a vadose investigation this year (DOE-RL 1993g). The unsaturated interval (vadose) is composed of unconsolidated gravelly sand of the Hanford formation and is approximately 64 m (210 ft) thick. The unconfined aquifer lies below and is within the silty, sandy gravels of the middle Ringold unit (see Figure 4.1-6, Section 4.1). Elevated concentrations of nitrate, CCl_4, and gross beta are being investigated under the groundwater assessment monitoring program.

4.3.1.2 Summary of 1993 Activities. The Washington State Department of Ecology (Ecology) notification of the elevated indicator parameter, specific conductance, above the background critical mean, and results of verification resampling, occurred on January 28, 1993, as required by 40 CFR 265.92(b)(3). The *Interim-Status Ground-Water Quality Assessment Plan for the 216-U-12 Crib* (WHC 1993) was submitted to Ecology on February 9, 1993. As outlined in the assessment plan, two existing wells, 299-W22-22 (downgradient) and 299-W22-23 (upgradient), were remediated and included as part of the assessment monitoring network.

Quarterly sampling of the four original RCRA network wells (Table 4.3-1) occurred in December 1992 (4th quarter), March (1st quarter), June and July (2nd quarter), and September (3rd quarter) 1993. The first quarterly sampling of remediated wells 299-W22-22 and 299-W22-23 occurred in July and August 1993, respectively.

Water level measurements were recorded at least once quarterly during well sampling. Monthly water level measurements in support of groundwater assessment began in September 1993. The monthly results will be reported in the subsequent RCRA quarterly reports. The summary and interpretation of quarterly monitoring results are presented in Section 4.3.3.

4.3.1.3 Other Activities in 1993. In addition to groundwater chemistry, the vadose zone below the U-12 Crib is being investigated as part of the *RCRA Facility Investigation/Corrective Measures Study Work Plan for the 200-UP-2 Operable Unit, Hanford Site* (DOE-RL 1993g). One vadose boring (299-W22-78) was drilled just downgradient of the U-12 Crib and between the two downgradient contaminant detection RCRA wells (Figure 4.3-1). Soil radiological and chemistry results, and subsurface geophysics are forthcoming and will be evaluated as part of a RCRA/CERCLA-integrated effort to assess contaminant source and distribution within the vadose at the U-12 Crib.

Table 4.3-1. Groundwater Monitoring Network.

Well	Aquifer	Sampling frequency	Water levels	Well standards	Other networks
299-W22-43[90]	Top of unconfined	Q	M	RCRA	Operational sitewide
299-W22-40[90]	Top of unconfined	Q	M	RCRA	Operational sitewide
299-W22-41[90]	Top of unconfined	Q	M	RCRA	Operational sitewide
299-W22-42[90]	Top of unconfined	Q	M	RCRA	Operational sitewide
299-W22-22[60]	Top of unconfined	Q	M	Pre-RCRA	Operational sitewide
299-W22-23[60]	Top of unconfined	Q	M	Pre-RCRA	--

Notes: Shading denotes upgradient wells. Superscript following well number denotes the year of installation.
M = frequency on a monthly basis.
Pre-RCRA = well constructed before RCRA-specified standards.
Q = frequency on a quarterly basis.
RCRA = well is constructed to RCRA-specified standards.

4.3.2 Sampling and Analysis Program

Sampling and analysis activities are conducted according to the U-12 Crib groundwater monitoring plan (WHC 1990) and as modified in the assessment plan (WHC 1993). The wells were sampled for contamination indicator parameters, groundwater quality parameters, drinking water standards (DWS), and site-specific parameters as identified in Table 4.3-2 (40 CFR 265). Site-specific parameters were selected based on a history of wastes disposed to the site and surrounding cribs, and groundwater monitoring results. Currently the monitoring network consists of six shallow monitoring wells completed at the top of the upper unconfined aquifer (Figure 4.3-2 and Table 4.3-1). Well construction information, including as-built diagrams, geologic and geophysical data, and aquifer test results, is documented in Goodwin (1990). Modifications to this network occurred this year with the addition of two existing wells as justified in the groundwater assessment monitoring plan (WHC 1993).

4.3.3 Groundwater Chemistry

The groundwater below the U-12 Crib has been monitored and analyzed as part of the RCRA program since September 1991. The site-specific waste indicators selected for the U-12 Crib include tritium, ^{99}Tc, uranium, and volatile organic analyses. Technetium-99 and tritium have been detected and are being investigated to determine if the U-12 Crib is the source. Summary

Figure 4.3-1. Well Location Map for the 216-U-12 Crib.

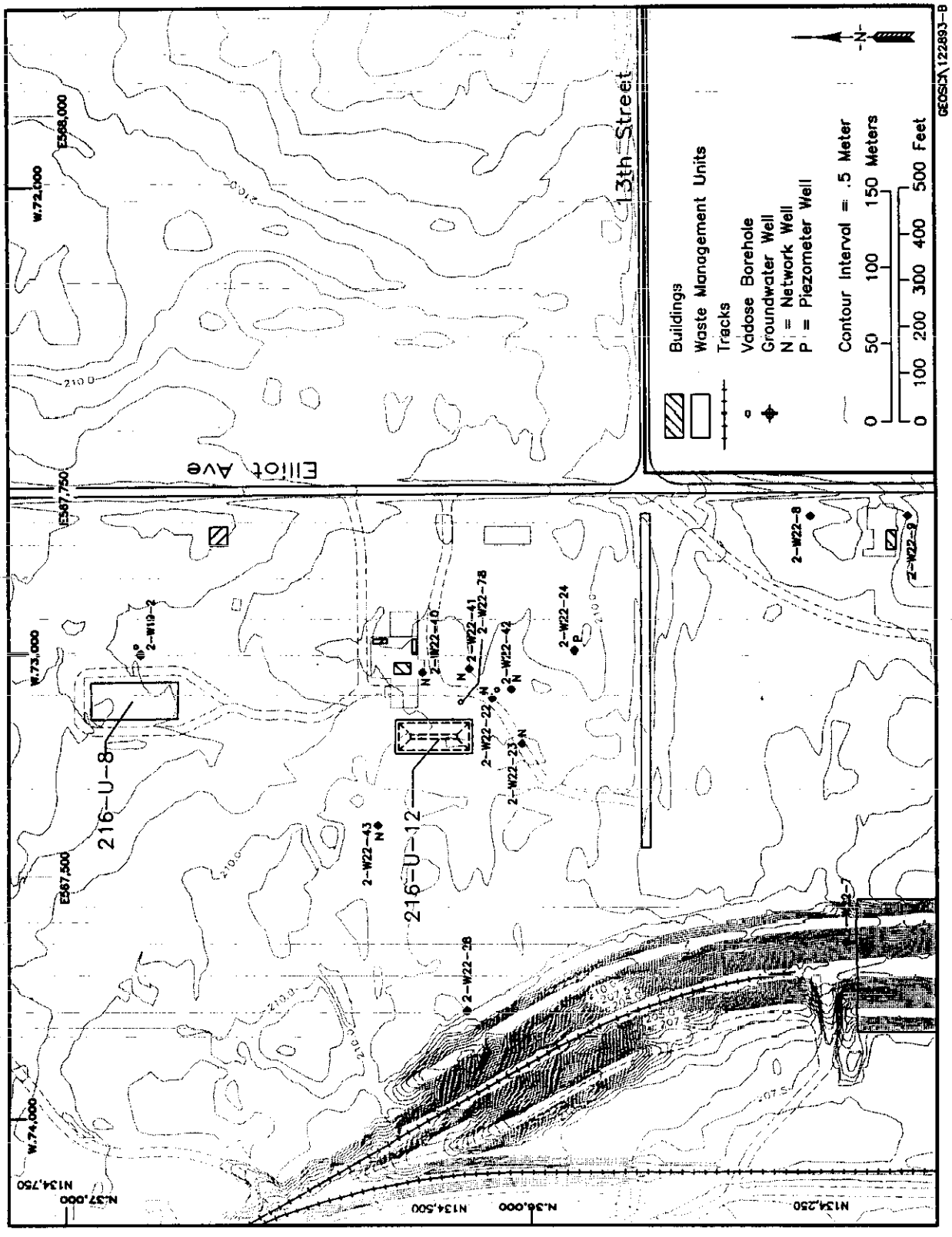

Table 4.3-2. Constituents Analyzed at the 216-U-12 Crib.

Contamination indicator parameters		
pH	Total organic carbon	
Specific conductance	Total organic halogen	
Groundwater quality parameters		
Chloride	Manganese	Sodium
Iron	Phenols	Sulfate
Drinking water parameters		
2,4-D	Endrin	Methoxychlor
2,4,5-TP Silvex	Fluoride	Nitrate
Arsenic	Gross alpha	Radium
Barium	Gross beta	Selenium
Cadmium	Lead	Silver
Chromium	Lindane	Toxaphene
Coliform bacteria	Mercury	Turbidity
Site-specific parameters		
Gamma scan	Uranium	
Gross beta	Volatile organic analysis	
Technetium-99		
Tritium		

and interpretation of the chemical and radiological results are being completed for all past data results and are evaluated with time-concentration graphs in Section 4.3.3.1. Only those constituents that may reflect a significant impact on the groundwater are discussed. Conclusions of the U-12 Crib assessment and a final report are due in July 1994.

4.3.3.1 Concentration Histories of Waste Indicators. Specific conductivity continued to be above the critical mean in downgradient wells 299-W22-41 and 299-W22-42 during 1993. Constituents that exceeded DWSs in the U-12 Crib groundwater monitoring network during 1993 are as follow: (1) nitrate, (2) CCl_4, and (3) unfiltered chromium and iron (see discussion in Section 2.2.4). In addition to these constituents, three radiological constituents, gross beta, ^{99}Tc, and tritium, have concentrations consistently higher in the two downgradient wells.

The contamination indicator parameter specific conductance has exceeded the site-specific critical mean (457.8 μmho/cm) in downgradient wells 299-W22-41 and 299-W22-42 since groundwater monitoring began (Figure 4.3-3). Nitrate is the only constituent with significantly consistent and elevated concentrations in the two downgradient wells (Figure 4.3-4) and, as such, is probably the cause of the elevated specific conductance.

Figure 4.3-2. Contour Map of the 216-U-12 Crib, June 1993.

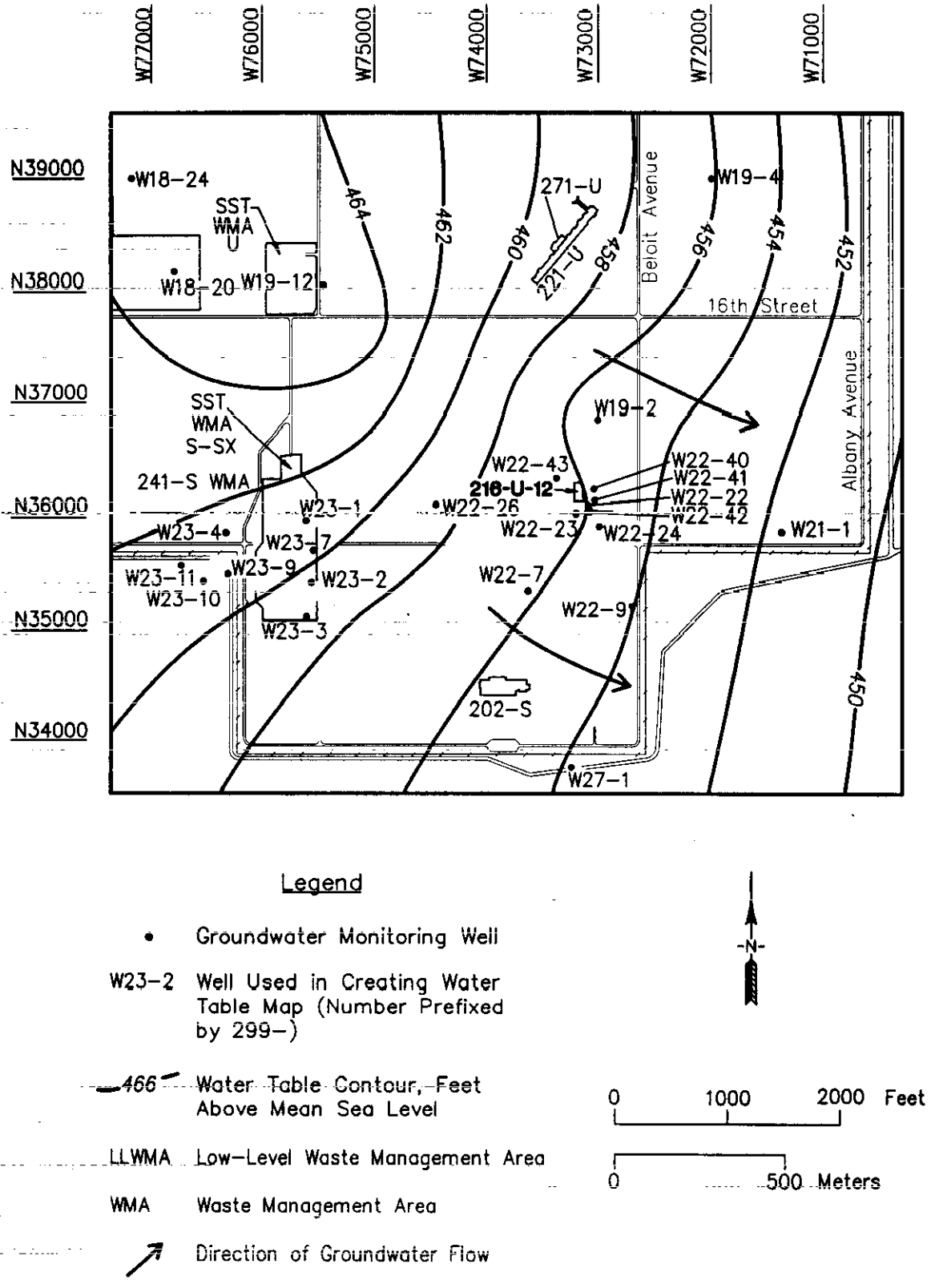

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Figure 4.3-3. Specific Conductivity at the 216-U-12 Crib.

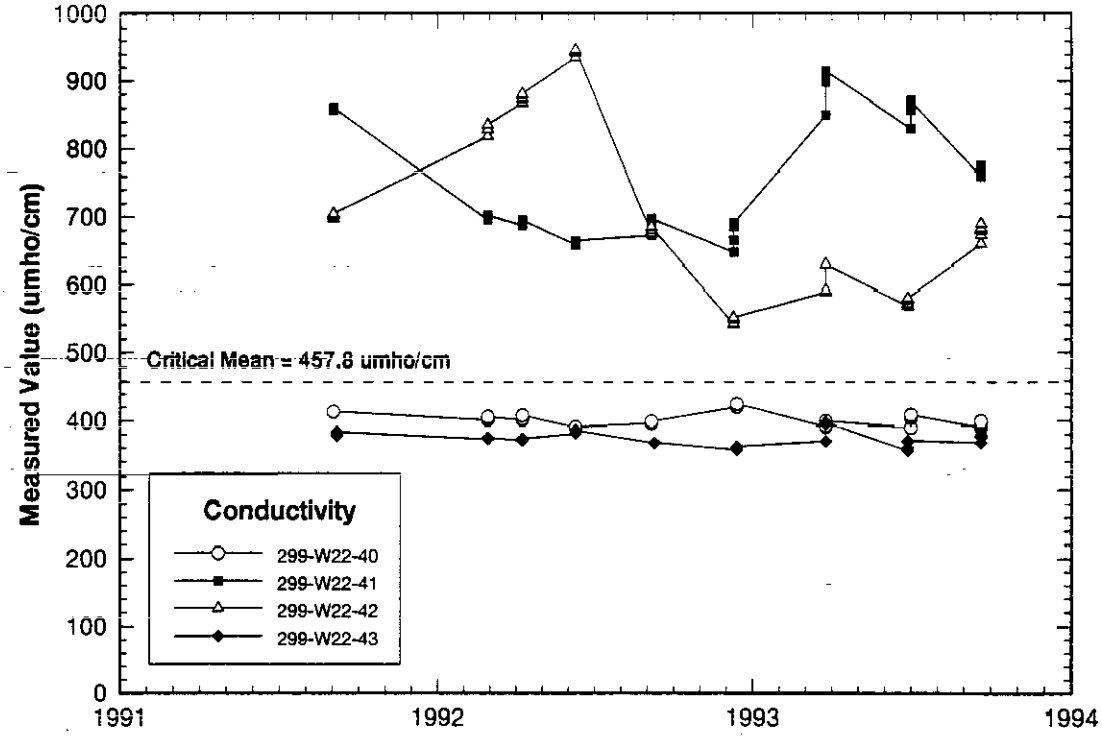
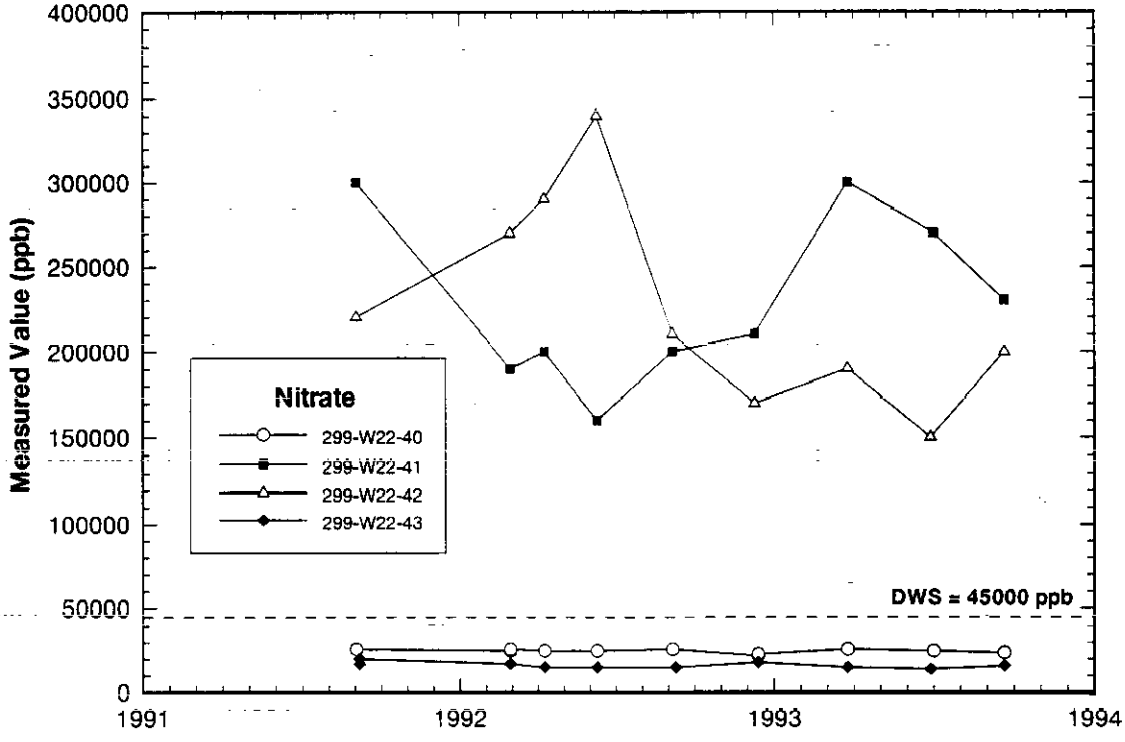


Figure 4.3-4. Nitrate Concentrations at the 216-U-12 Crib.



Documented releases of dilute nitric acid to the U-12 Crib during its operation substantiate this interpretation. Initial data evaluation suggests that the U-12 Crib may be the source of this contamination.

Nitrate concentrations have continued to exceed the 45,000-ppb DWS and are 10 times above the average upgradient background value. The elevated concentration trends (see Figures 4.3-3 and 4.3-4) in the two downgradient wells have remained relatively unchanged since the monitoring began. While inconclusive, it is believed that slugs or seeps of residual effluent are still moving downward in the vadose zone and contaminating the aquifer even though all effluent disposal to the U-12 Crib ceased in 1988. The fluctuations are a result of this noncontinuous effluent migration and heterogeneities within the aquifer. Concentration trends are expected to remain constant and eventually decline as the vadose drains (source volume decreases).

Monitoring at downgradient well 299-W22-40 has not detected any nitrate contamination; it is most likely outside the flowpath of the U-12 Crib nitrate plume (see Figure 4.1-29, Section 4.1). This is supported by mapping flow lines on the water table map. The spatial relationship of the monitoring network, with respect to the detected contamination, indicates that the current source is already restricted and of relatively low volume and high concentration. This is expected because effluent disposal ceased over 5 years ago. It is quite conceivable that a much larger undetected plume of contamination lies downgradient of the current monitoring network when taking into consideration the history of effluent volumes disposed at the facility in the past (see Section 4.3.1.1). The nitrate contamination detected thus far may actually be the tail of this undetected plume. This is further evidenced by the regional nitrate plume (see Figure 4.1-29, Section 4.1), which exhibits an unusual asymmetrical distribution. The skewed portion of this plume surrounds the U-12 Crib. Current downgradient well spacing is very limited and reduces the accuracy of plume mapping in the area. Future investigation of this hypothesis, e.g., additional drilling, may be conducted as determined from ongoing assessment studies.

Radiological gross beta contamination has also been detected in downgradient wells 299-W22-41 and 299-W22-42 since monitoring began (Figure 4.3-5). While none of the concentrations exceeded the 50-pCi/L DWS, several values have been close and prudent operations dictate the inclusion of this constituent in the assessment investigation. Technetium-99 is the only specific beta-emitting radionuclide with above background concentrations (Figure 4.3-6). The comparable concentration trends substantiate this site-specific constituent as the primary source of the high beta. The ^{99}Tc plume exhibits a distribution similar to the nitrate plume. Trends reflect a consistent, low-volume source emanating from below the U-12 Crib. A review of the regional technetium plume (see Figure 4.1-36, Section 4.1) reveals an asymmetrical plume shape similar to nitrate. The skewed portion in the plume is toward the U-12 Crib. Concentration trends of both beta and ^{99}Tc throughout the monitoring life have fluctuated somewhat but appear to be relatively stable. As with the nitrate plume, the concentrations are expected to decrease over time and these data may hint at a larger plume downgradient of the current monitoring system. These constituents will be monitored and evaluated as part of the nitrate investigation.

Figure 4.3-5. Gross Beta Activity at the 216-U-12 Crib.

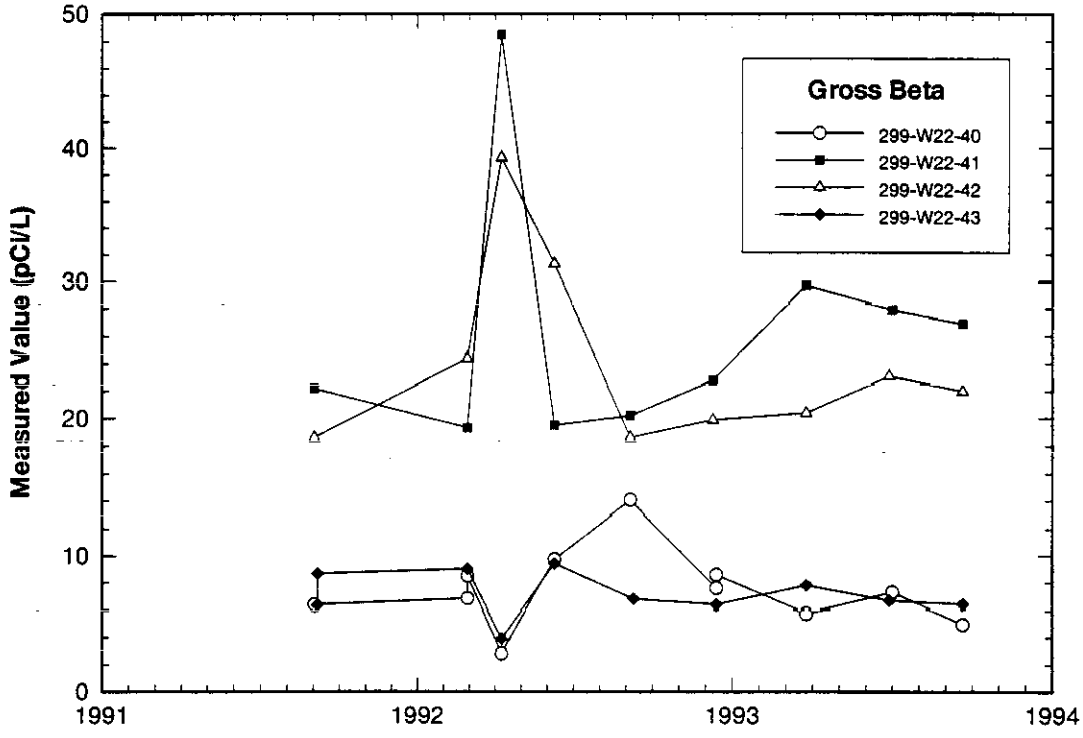
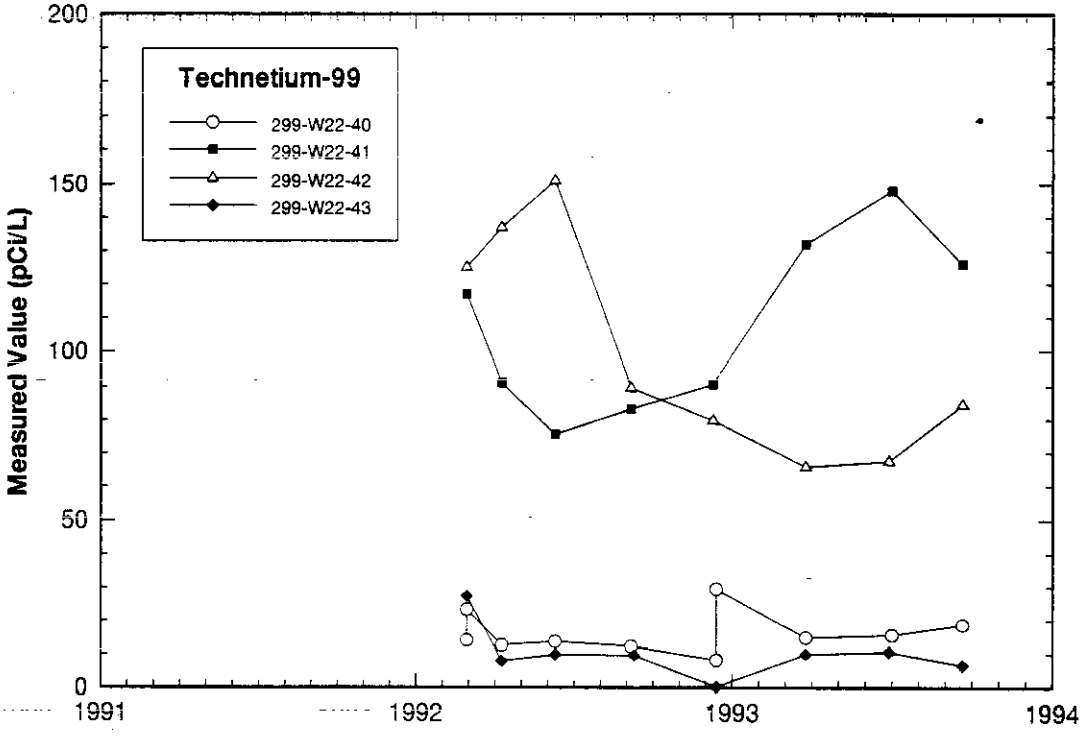


Figure 4.3-6. Technetium-99 Activity at the 216-U-12 Crib.



The long-term concentration trend for tritium in well 299-W22-42 indicates that this well probably is detecting some contaminant release from the U-12 Crib (Figure 4.3-7). This constituent, while not exceeding the DWS, will also be evaluated as part of the U-12 Crib assessment. Tritium is not a documented component of the effluent disposed at the facility.

Carbon tetrachloride concentrations have predominantly exceeded the DWS (5 ppb) in all network wells since RCRA monitoring began (Figure 4.3-8). The contaminant source is not the U-12 Crib; there is no documented record of CCl_4 disposal into the U-12 Crib. The concentrations detected at the U-12 Crib network are a component of the large CCl_4 plume whose source(s) is upgradient of this facility (see Figure 4.1-19, Section 4.1). The CCl_4 data reported for the U-12 Crib, while not site specific, do provide additional data for tracking and mapping the regional plume. Based on the plume migration path, the concentration trends throughout the monitoring life of the facility are expected to remain relatively flat and then decrease with time as the plume migrates away from the area.

All available data results are presented in the quarterly reports for RCRA groundwater monitoring data from October 1, 1991 through September 30, 1993 (DOE-RL 1991, 1992a, 1992b, 1992c, 1993b, 1993c, 1993d, 1993e, 1993f).

4.3.4 Groundwater Flow

4.3.4.1 Groundwater Flow Direction. Declining groundwater levels for the U-12 Crib network are shown in the hydrograph in Figure 4.3-9. The groundwater below the U-12 Crib has declined on average over 0.45 m (1.5 ft) since the last annual report. Water levels are reported in previous quarterly reports. Figure 4.3-2 depicts the contoured water table elevations for June 1993. The water elevations reveal an east-southeasterly flow direction that coincides with the regional groundwater map presented in Figure 4.1-13, Section 4.1. This flow direction remains unchanged from 1992 to 1993. Based on this information, the wells are appropriately located to detect contaminant discharges from the U-12 Crib.

4.3.4.2 Groundwater Flow Rate. The rate of groundwater flow beneath the U-12 Crib is relatively unchanged and consistent to last year. The aquifer beneath the U-12 Crib is characterized by relatively low hydraulic conductivities 2 to 13 m/d (8 to 44 ft/d) and a moderate gradient. The upper aquifer is composed of silty, sandy gravel that exhibits variable or heterogeneous flow conditions. Evaluation of the hydraulic gradient over the past several years reveals essentially no change in decline rate. The average gradient measured across the U-12 Crib is 0.0025. Site-specific aquifer testing is limited to slug test results. Based on these tests, groundwater

Figure 4.3-7. Tritium Activity at the 216-U-12 Crib.

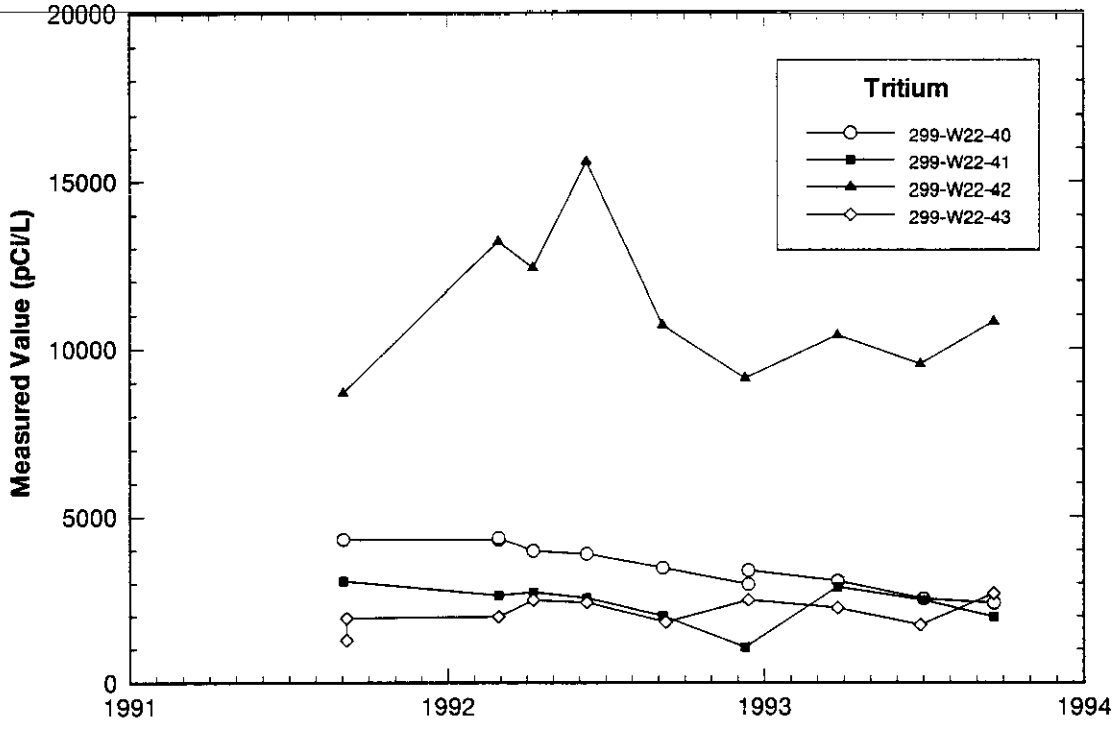


Figure 4.3-8. Carbon Tetrachloride Concentrations at the 216-U-12 Crib.

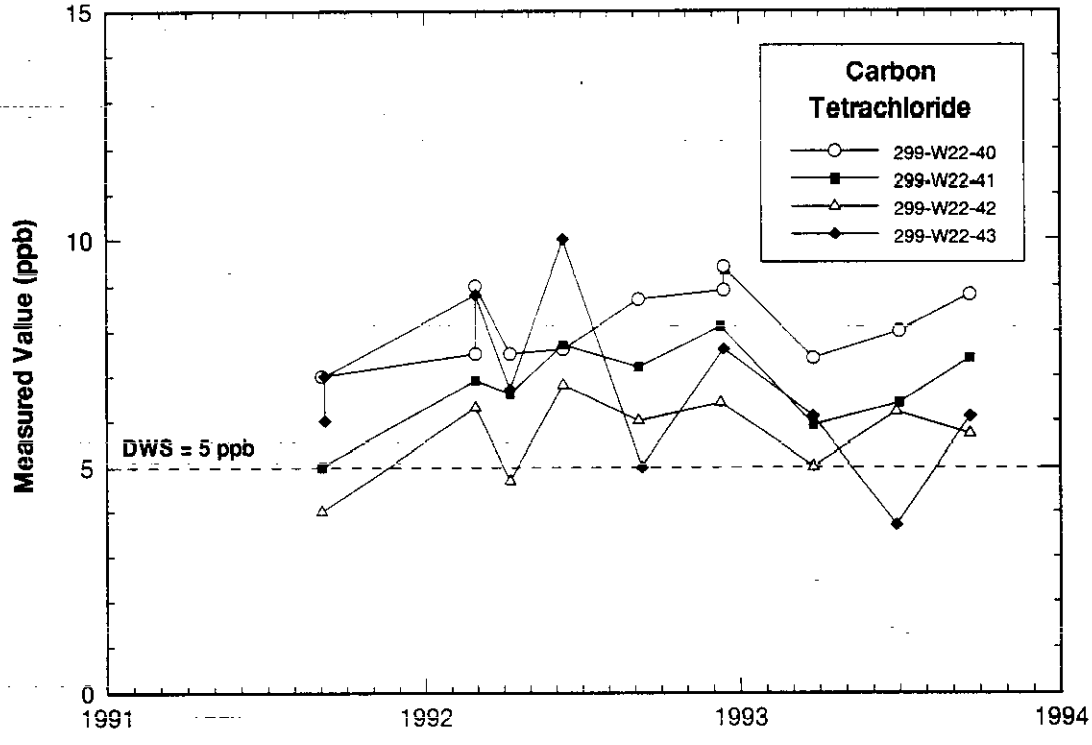
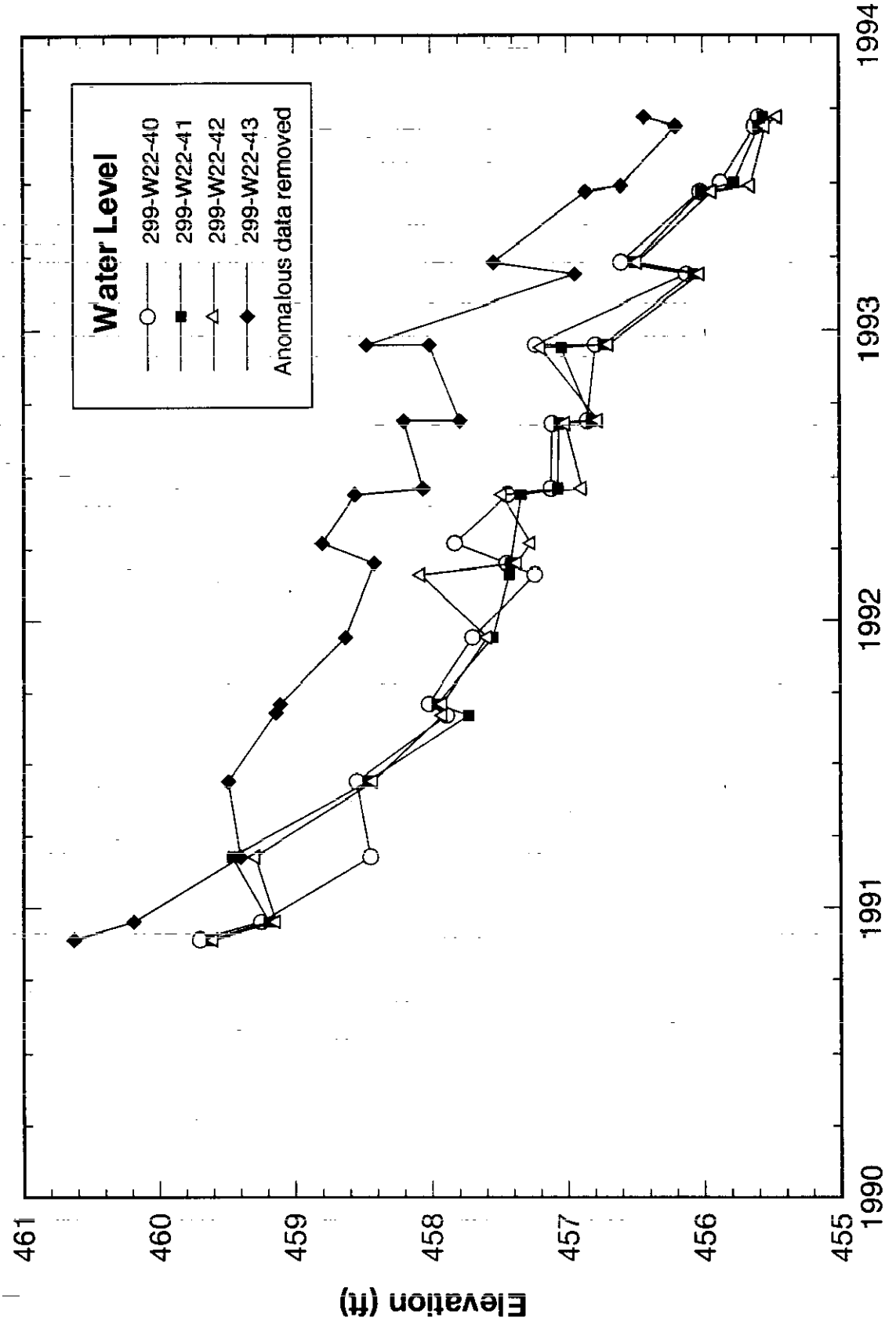


Figure 4.3-9. Composite Hydrograph of Quarterly Water Level Measurements (Feet Above Sea Level) at the 216-U-12 Facility.



velocities range from 0.03 to 0.2 m/day (0.1 to 0.6 ft/day). These calculations are estimates based on the Darcy average linear groundwater flow equation

$$v = \frac{Ki}{n} \quad (1)$$

where:

v = Average linear velocity (ft/d)
K = Hydraulic conductivity (ft/d)
i = Hydraulic gradient (ft/ft)
n = Effective porosity.

The range of K is calculated by Goodwin (1990) and is from 2 to 13 m/d (8 to 44 ft/d). Effective porosity is estimated at 0.2 and the gradient is calculated above from June 1993 water table results.

To date no other methods (plume transport velocities and tracer testing) have been used to determine or confirm groundwater velocities at the U-12 Crib.

4.3.4.3 Evaluation of Monitoring Well Network. Because of the unchanged groundwater flow direction, the wells are appropriately located to assess contaminant discharges from the U-12 Crib. Water levels are measured regularly and the adequacy of the existing monitoring network is evaluated accordingly based on the ability of the downgradient wells to detect contamination at the point of compliance. The original detection monitoring network was designed based on the MEMO model (Jackson et al. 1991) to provide leak detection monitoring efficiency for an estimated 90% of the U-12 Crib.

As a result of contamination detected in wells 299-W22-41 and 299-W22-42, two additional wells were added to the network this year as part of the assessment to provide more detailed information for plume evaluation and source determination. Well 299-W22-22 is located between the two wells that detected the contamination and slightly upgradient. Results from this well should confirm the U-12 Crib as the source. Well 299-W22-23 is located adjacent and slightly upgradient to the U-12 Crib and should provide data to support the absence of upgradient contaminant sources. Sampling of the two older wells has been somewhat encumbered because of limited perforated open intervals, which has created restricted groundwater flow into the well, thus causing difficulty retrieving representative samples.

Under current conditions no additional well installations are required. Additional remediation of the two older, pre-RCRA design wells will continue as needed to maintain sample-ready wells.

Based on Phase I assessment at the U-12 Crib, additional downgradient wells may be needed to determine the extent of contaminant migration as part of Phase II of the assessment plan (WHC 1993).

4.3.5 References

40 CFR 265, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," *Code of Federal Regulations*, as amended.

Comprehensive Environmental Response, Compensation, and Liability Act of 1980, 42 USC 9601 et seq.

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DOE-RL, 1992c, *Quarterly Report of RCRA Groundwater Monitoring Data for Period April 1, 1992 through June 30, 1992*, DOE/RL-92-26-2, U.S. Department of Energy, Richland Field Office, Richland, Washington.

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DOE-RL, 1993b, *Quarterly Report for RCRA Groundwater Monitoring Data for Period July 1, 1992 through September 30, 1992*, DOE/RL-92-26-3, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

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Resource Conservation and Recovery Act of 1976, 42 USC 6901 et seq.

WHC, 1990, *Interim-Status Ground-Water Monitoring Plan for the 216-U-12 Crib*, WHC-SD-EN-AP-019, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

WHC, 1993, *Interim-Status Ground-Water Quality Assessment Plan for the 216-U-12 Crib*, WHC-SD-EN-AP-103, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

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4.4 GROUT TREATMENT FACILITY

L. C. Swanson
Westinghouse Hanford Company

4.4.1 Facility Overview

The Grout Treatment Facility (GTF) is a treatment and disposal facility regulated under *Resource Conservation and Recovery Act of 1976* (RCRA) interim-status regulations (40 *Code of Federal Regulations* [CFR] 265) and *Washington Administrative Code* "Dangerous Waste Regulations" (WAC 173-303). The site has not received dangerous waste to date. Detailed dangerous waste permit information for the GTF is provided in Part B of the current dangerous waste permit application (DOE-RL 1992).

The GTF is in a RCRA indicator parameter evaluation monitoring program in accordance with interim-status regulations set forth in 40 CFR 265, Subpart F, and as outlined in the *Interim Status Ground-Water Monitoring Plan for the Grout Treatment Facility* (Teel et al. 1989). The facility is located in the 200 East Area of the Hanford Site (see Figure 1-1, Chapter 1.0; Figure 4.4-1), and is contained in the 200-PO-5 groundwater operable unit. Refer to Section 4.1 for a description of the geology.

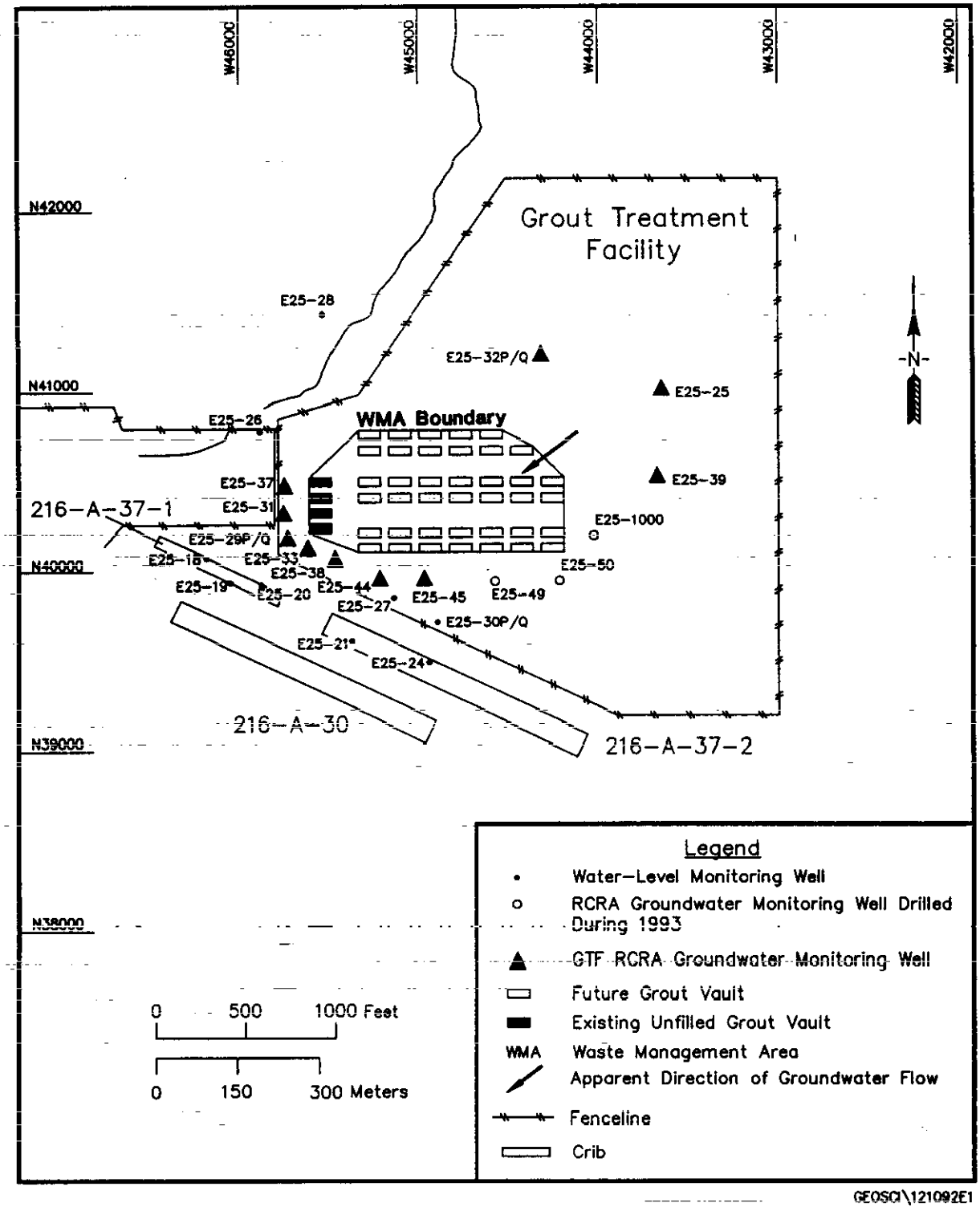
Grout treatment is a process that involves blending a slurry of selected, mixed radioactive and hazardous (dangerous) liquid wastes with grout-forming solids and chemical additives. This slurry is then poured into subterranean vaults for hardening (curing) to produce a massive, stabilized cement-like block, suitable for in-place, long-term disposal. Each vault is considered a RCRA surface impoundment while the grout slurry hardens. After the grout hardens, the vault is sealed and closed as a RCRA-permitted landfill. One vault was filled with a phosphate/sulfate mixture during a demonstration campaign (pouring) conducted from August 1988 to July 1989. The grout mixture for this first campaign was not considered a designated dangerous waste, although it did contain low levels of radioactive substances.

4.4.2 Summary of 1993 RCRA Activities

The GTF was placed into cold standby after the conclusion of *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1992) renegotiations between Washington State Department of Ecology (Ecology), U.S. Environmental Protection Agency (EPA), and the U.S. Department of Energy (DOE). The three parties agreed in principle to exclude the use of grouting as a disposal strategy. A finalized change request to the Tri-Party Agreement was approved in January 1994.

In response to the status change, the groundwater monitoring and sampling program was put on hold in November 1993. Groundwater samples are no longer collected from the monitoring network in support of the GTF. Outstanding laboratory analysis results for groundwater samples collected before November 1993 will be reported in RCRA quarterly reports as they are received from the laboratory. After final sample results are reported, the GTF section will be removed from the quarterly reports. The GTF will not be included in

Figure 4.4-1. RCRA Monitoring Well Locations for the Grout Treatment Facility.



next year's annual report. However, some of the GTF monitoring wells will be sampled in support of other 200 East Area sites and activities (e.g., the 216-A-29 Ditch, tracking of 200 East Area groundwater plumes, and 200 East Area water table maps).

In 1993 groundwater sampling and water level measurements were taken quarterly or semiannually at most of the wells (Table 4.4-1). Vault construction work prevented collection of groundwater samples at wells 299-E25-31, 299-E25-33, and 299-E25-37 until April 1993. Quarterly monitoring reports for the GTF were prepared in accordance with RCRA requirements and forwarded to Ecology (DOE-RL 1993b, 1993c, 1993d, 1993e). Other RCRA activities at the GTF during 1993 included:

- Remediation or modification of monitoring network wells 299-E25-31, 299-E25-33, and 299-E25-37
- Drilling and completion of groundwater monitoring wells 299-E25-49, 299-E25-50, and 299-E25-1000
- Completion of the borehole completion data package for wells 299-E25-44 and 299-E25-45 (Swanson 1993a).

Wellhead modifications were required at wells 299-E25-31 and 299-E25-37, because vault pit construction activities damaged the surface seals. A revised borehole completion data package that documented the modifications was forwarded to Ecology (Swanson 1993b). The surface seals do comply with Ecology's "Minimum Standards for Construction and Maintenance of Wells," WAC 173-160.

A platform was constructed around well 299-E25-33 to provide access to the well for groundwater sampling after additional casing was added to the well to accommodate backfilling operations in the GTF pit. Because the pit was not backfilled to the anticipated elevation, about 4.6 m (15 ft) of casing remained above ground surface. Groundwater sampling was reinitiated in April 1993.

Three new monitoring wells were drilled and completed this year: 299-E25-49, 299-E25-50, and 299-E25-1000. Figure 4.4-1 shows the locations of these wells. These three wells complete the groundwater monitoring network as described in the Part B dangerous waste permit application (DOE-RL 1992). Well 299-E25-1000 was drilled as a characterization borehole to the top of basalt. A borehole completion data package will be issued for these wells in 1994. A borehole completion data package was released the first quarter of 1993 for wells 299-E25-44 and 299-E25-45, which were drilled and completed in 1992.

4.4.3 Sampling and Analysis Program

Thirteen wells comprise the RCRA indicator detection monitoring network for the GTF as follows: (1) nine downgradient and (2) four upgradient wells. Groundwater samples will not be collected at the three new monitoring wells or any of the existing monitoring wells in support of the GTF program because of the cold standby status (see Section 4.4.2).

Table 4.4-1. Grout Treatment Facility 1993 Groundwater Monitoring Wells. (sheet 1 of 2)

Well	Aquifer	Sampling frequency	Water levels	Well standards	Other networks
299-E25-25[85u]	Upper unconfined	Q	S	PRE	--
299-E25-31[87d]	Top of unconfined	Q	Q	RCRA	A-29
299-E25-32P[88u]	Top of unconfined	Q	M	RCRA	B Pond A-29
299-E25-33[88d]	Top of unconfined	Q	S	RCRA	--
299-E25-37[89d]	Top of unconfined	Q	S	RCRA	--
299-E25-38[89d]	Top of unconfined	Q	S	RCRA	--
299-E25-39[90u]	Top of unconfined	Q	S	RCRA	--
299-E25-44[92d]	Top of unconfined	Q	S	RCRA	--
299-E25-45[92d]	Top of unconfined	Q	S	RCRA	--
299-E25-49[93d]	Top of unconfined	N/A[a]	Q	RCRA	--
299-E25-50[93d]	Top of unconfined	N/A[a]	Q	RCRA	--
299-E25-1000[93u]	Top of unconfined	N/A[a]	Q	RCRA	--
299-E25-29P[87d]	Top of unconfined	Q	S	RCRA	--
299-E25-29Q[87]	Top of unconfined	--	S	RCRA	--
299-E25-30P[87]	Top of unconfined	--	S	RCRA	--
299-E25-30Q[87]	Deep unconfined	--	S	RCRA	--
299-E25-28[86]	Deep unconfined	Q	M	RCRA	A-29
299-E25-32Q[88]	Deep unconfined	--	S	RCRA	--
299-E25-18[76]	Top of unconfined	--	S	PRE	--
299-E25-20[76]	Top of unconfined	--	S	PRE	--

Table 4.4-1. Grout Treatment Facility 1993 Groundwater Monitoring Wells. (sheet 2 of 2)

Well	Aquifer	Sampling frequency	Water levels	Well standards	Other networks
299-E25-24[83]	Top of unconfined	--	S	PRE	--
299-E25-26[85]	Upper unconfined	Q	M	RCRA	A-29
299-E25-27[85]	Upper unconfined	--	S	PRE	--

Notes: Shading denotes upgradient wells. Superscript following well number denotes the year of installation, followed by a "u" or "d," indicating whether the well is a downgradient or upgradient monitoring well. All other wells are used for water level measurements only. Water levels also are measured at the time of water chemistry sampling.

Deep unconfined = wells screened at approximately 18.3 m (60 ft) below the water table.
Top of unconfined = wells screened above and below the water table.
Upper unconfined = wells screened completely below the water table (top of screened interval about 1.5 m [5 ft] below the water table).

[a]All sampling of the GTF wells is on hold because of renegotiation of the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1992). These three wells were just completed in calendar year 1993.

M = frequency on a monthly basis.
N/A = not available.
PRE = well was constructed before RCRA-specified standards.
Q = frequency on a quarterly basis.
RCRA = well is constructed to RCRA-specified standards.
S = frequency on a semiannual basis.

The GTF network monitoring wells and other supplemental water level monitoring wells are listed in Table 4.4-1. Locations of monitoring wells relative to the GTF are shown in Figure 4.4-1. All GTF monitoring wells were constructed according to WAC 173-160, and from guidance provided in EPA (1986), except well 299-E25-25, which was built before publication of the RCRA guidance document. Nevertheless, this monitoring well is considered acceptable for RCRA monitoring purposes (Teel et al. 1989).

Sampling and analysis activities were conducted according to the GTF facility groundwater monitoring plan (Teel et al. 1989). Table 4.4-2 is a list of groundwater chemical constituents analyzed at the GTF. These constituents are required by RCRA regulations, and are specified in the Part B Permit dangerous waste application (DOE-RL 1992).

Table 4.4-2. Constituent List for the Grout Treatment Facility.

Contamination indicator parameters		
pH	Total organic carbon	
Specific conductance	Total organic halogens	
Groundwater quality parameters		
Chloride	Manganese	Sodium
Iron	Phenols	Sulfate
Drinking water parameters		
2,4-D	Endrin	Methoxychlor
2,4,5-TP Silvex	Fluoride	Nitrate
Arsenic	Gross alpha	Radium
Barium	Gross beta	Selenium
Cadmium	Lead	Silver
Chromium	Lindane	Toxaphene
Coliform bacteria	Mercury	Turbidity
Site-specific parameters		
Arsenic	Selenium	
Chromium	Technetium-99	

4.4.4 Groundwater Chemistry

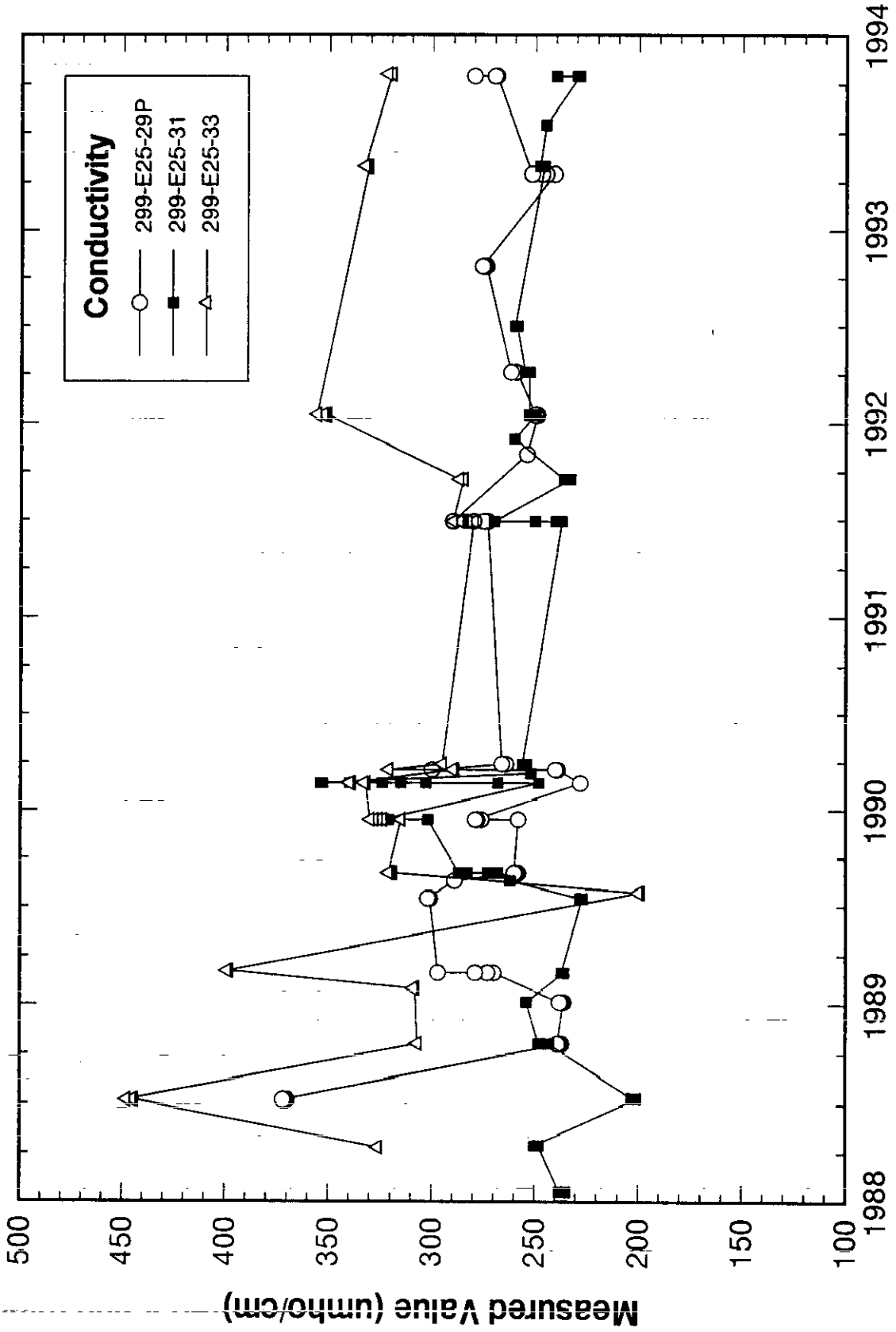
This report covers groundwater data collected from October 1992 through September 1993. Most groundwater chemistry data for this period were reported in quarterly reports for the periods of October 1 to December 31, 1992; January 1 to March 31, 1993; April 1 to June 30, 1993; and July 1 to September 30, 1993 (DOE-RL 1993b, 1993c, 1993d, 1993e).

4.4.4.1 Constituents of Concern.

4.4.4.1.1 Indicator Parameters. Groundwater sample results for the general contamination indicator parameters of pH, specific conductance (SC), total organic carbon, and total organic halogen (TOX) followed historical trends. The statistical critical mean was not exceeded for any of the indicator parameters, except at well 299-E25-33 where the SC regularly and historically exceeds the critical mean of 291.6 μmho/cm (Figure 4.4-2). In general, TOX laboratory results are unusable because of a 1993 audit finding. These data are flagged with a "P" in quarterly report data tables. See Appendix A for a pertinent discussion of the problems with the TOX data.

The high SC at well 299-E25-33 is not the result of releases from the GTF, because no hazardous waste has been disposed to the vaults. The most likely cause for the elevated readings is the 216-A-37-1 disposal crib located

Figure 4.4-2. Plot of Specific Conductance for Select Downgradient Wells.



southwest of this well. SC readings are elevated in crib wells 299-E25-18, 299-E25-19, and 299-E25-20, and are of the same magnitude as well 299-E25-33 (300 to 500 μmho/cm; Figure 4.4-3).

The pH value in October 1993 at downgradient well 299-E25-37 was reported at 6.8. This value is lower than the historical levels at the well. The reason for the variance is not known, although it may be related to the well remediation activities performed earlier in the year. The pH did not exceed the drinking water standard (DWS) or fall outside the range of the critical mean.

One intriguing relationship was noted between the pH and the SC at well 299-E25-32P. As shown in Figure 4.4-4, these measurements appear to change in an inversely proportional manner. The reason for this correlation is not fully understood.

4.4.4.1.2 Site-Specific Parameters. Four site-specific parameters are designated as additional monitoring parameters in the GTF Part B permit application (DOE-RL 1992). These parameters are arsenic, chromium, selenium, and ^{99}Tc. Generally, the constituents were below DWSs or are consistent with historical concentrations and trends. However, unfiltered metal concentrations such as chromium and iron were significantly higher than the filtered metals. This situation is common to most of the RCRA sites. Section 2.2.4 discusses this phenomenon.

The upgradient and downgradient wells had similar concentrations of ^{99}Tc at about 1 pCi/L. One unusually high value was noted at well 299-E25-44 from the April 16, 1993 sampling. The concentration was reported at 12.6 pCi/L, which is one order of magnitude higher than historical values. The reason for the high concentration has not been determined.

Filtered arsenic concentrations were above the contractually required quantitation limits (CRQL) at the downgradient wells (see Figure 4.4-11) and below the CRQL of 5 ppb at the upgradient wells. The source of the higher downgradient arsenic concentrations is probably the nearby 216-A-37-1 and 216-A-37-2 Cribs. Arsenic concentrations at these two cribs and the GTF downgradient wells are roughly equivalent between 5 and 15 ppb (Figures 4.4-5 and 4.4-6; also see regional plume map, Section 4.1).

4.4.4.1.3 Water Quality Parameters. Water quality parameters were consistent with historical trends. Turbidity values did exceed the surface water standard of 1 nephelometric turbidity unit (NTU) at several wells. However, these exceedances were generally less than 5 NTUs, which is higher than the surface water standard, but less than the Hanford Site well development criteria of 5 NTUs. These values are not unexpected based on the level of well development performed at RCRA wells.

4.4.4.1.4 Trends. In the last annual report (DOE-RL 1993a) it was reported that tritium concentrations appeared to be increasing in all of the upgradient and two of the downgradient wells in 1992. Since that time the tritium values have leveled off or dropped slightly (Figures 4.4-7 and 4.4-8).

Figure 4.4-3. Plot of Specific Conductance for 216-A-37-1 Crib Wells.

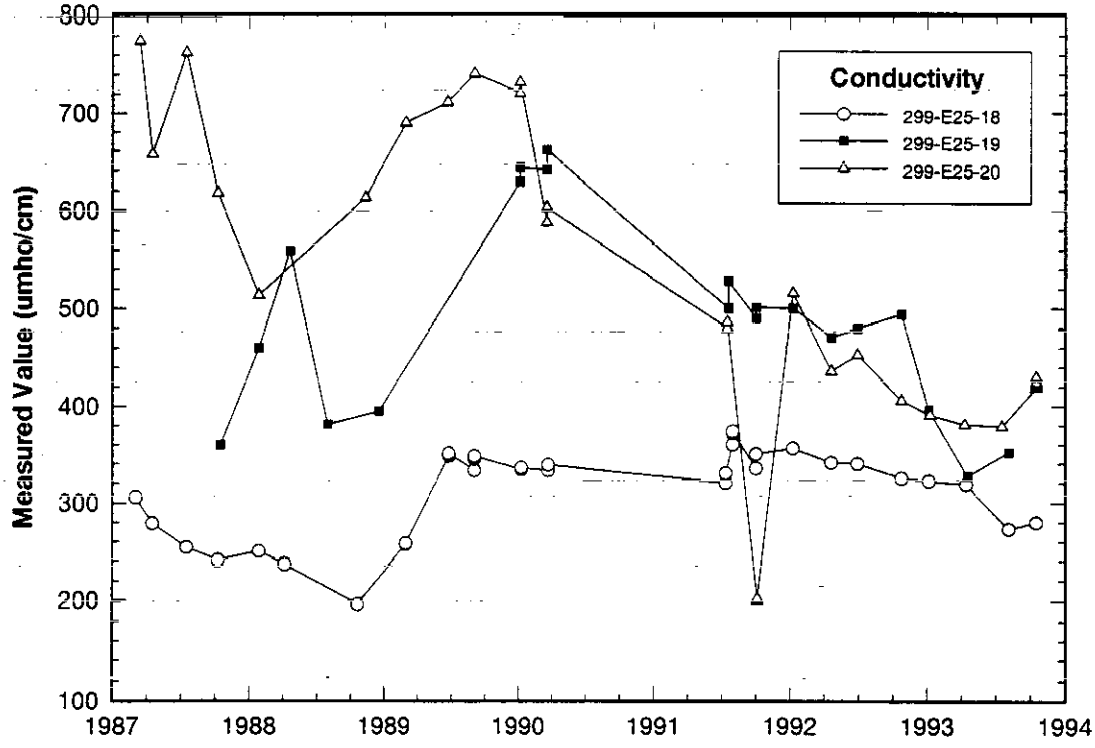


Figure 4.4-4. Plot of pH Versus Specific Conductance for Well 299-E25-32P.

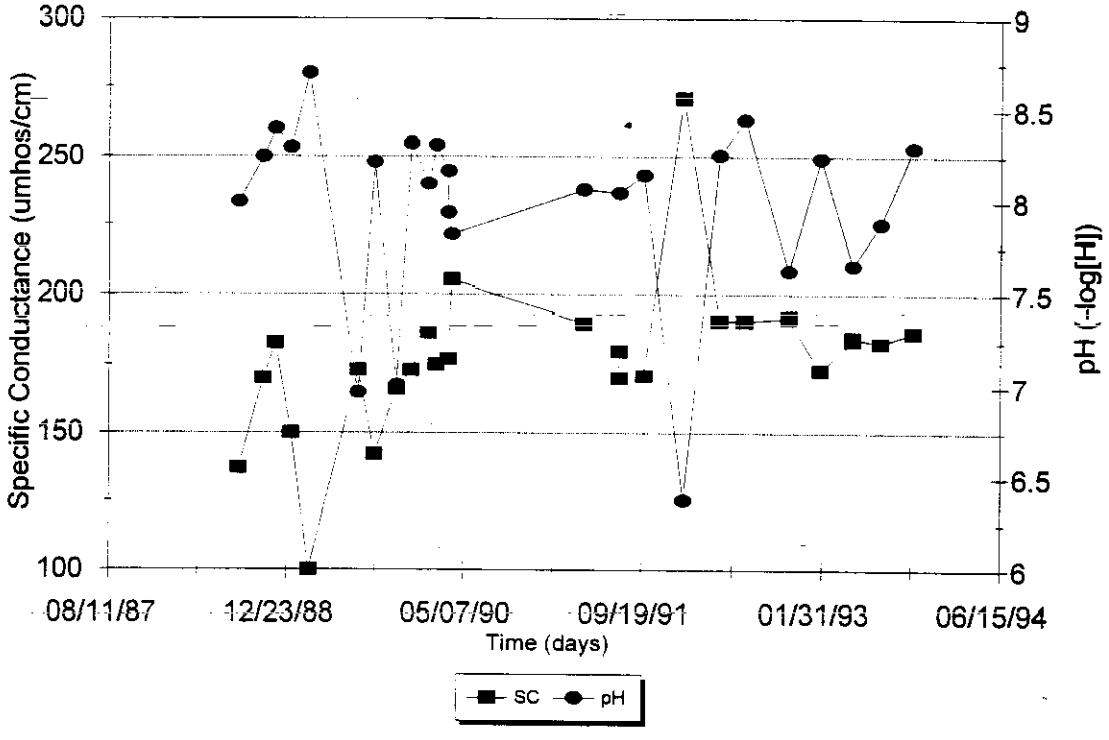


Figure 4.4-5. Concentration Plot for Filtered Arsenic at Select Downgradient Wells.

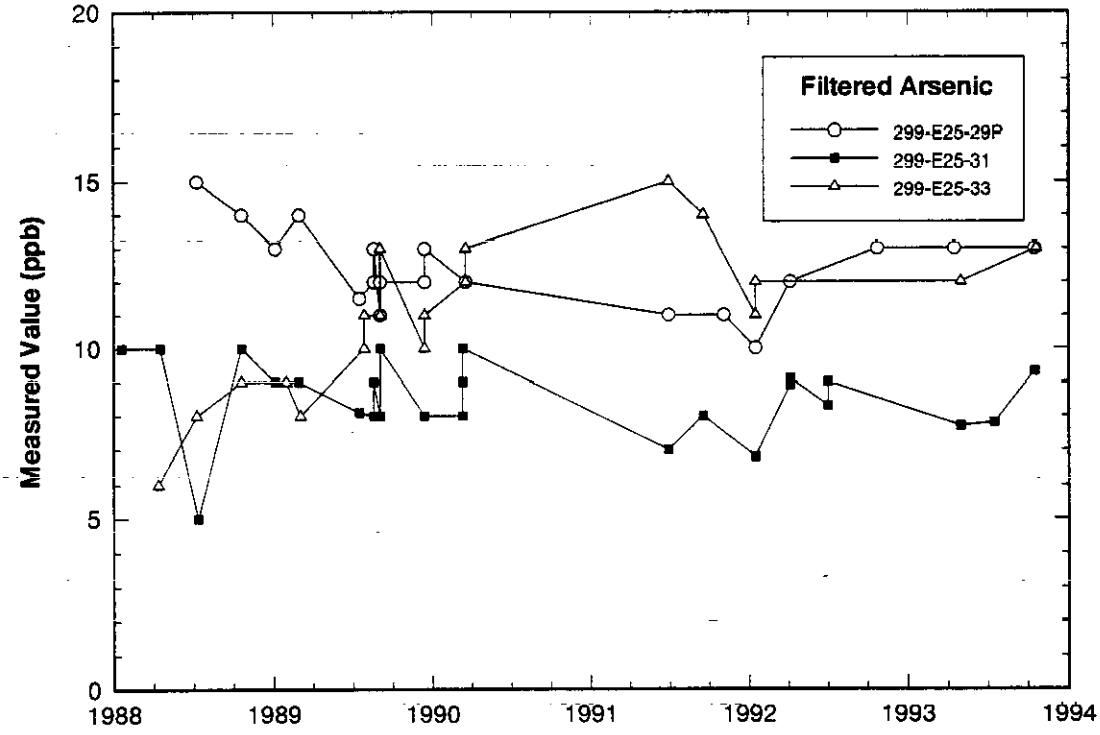


Figure 4.4-6. Concentration Plot for Filtered Arsenic at 216-A-37-2 Crib Wells.

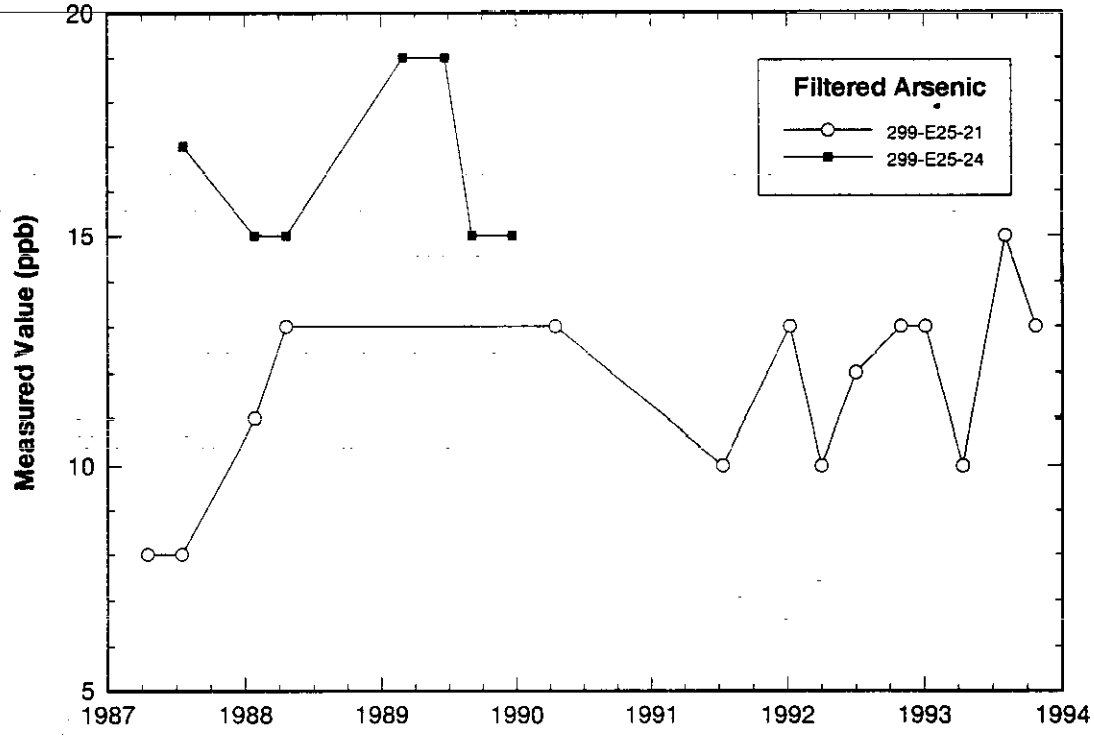


Figure 4.4-7. Concentration Plot for Tritium at Upgradient Wells.

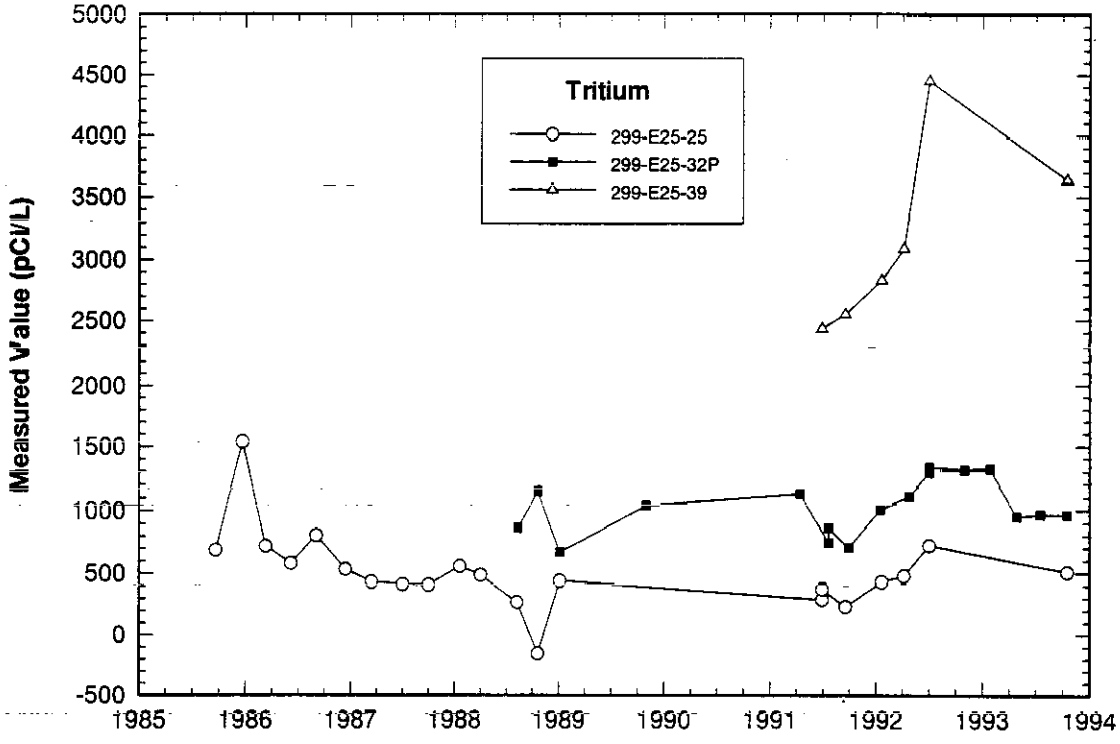
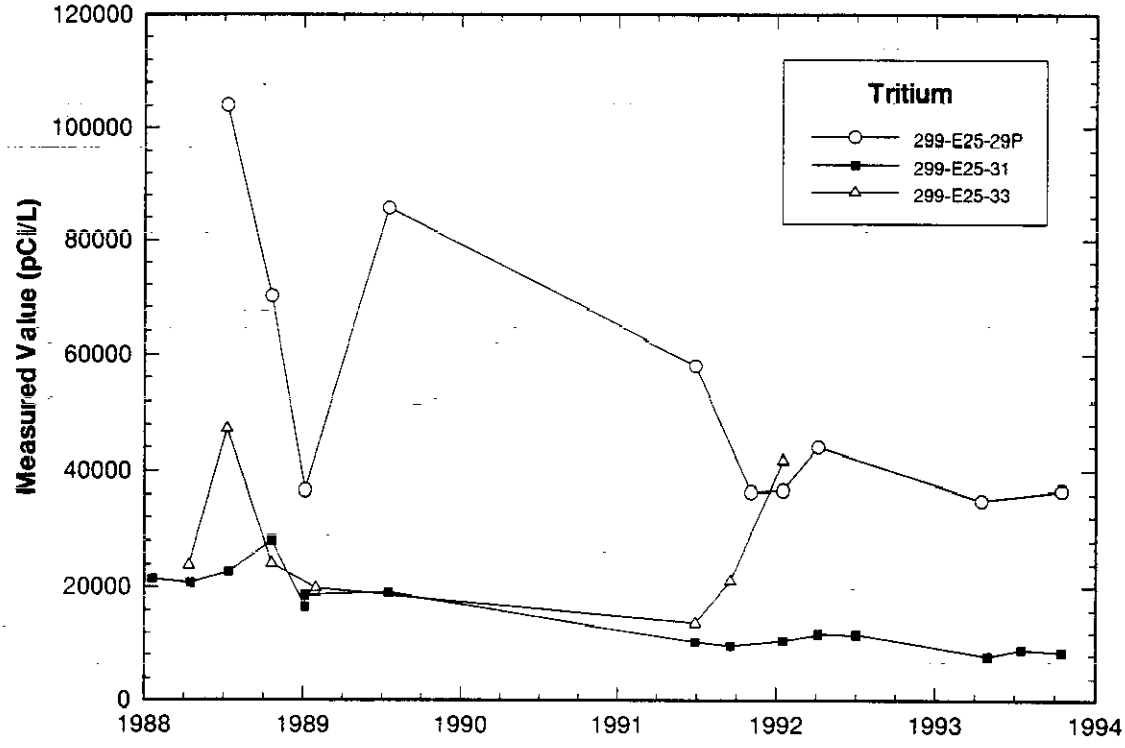


Figure 4.4-8. Concentration Plot for Tritium at Downgradient Wells.



The highest tritium concentrations are observed in the downgradient wells, which are closest to the 216-A-37-1 Crib. Tritium concentrations in the downgradient GTF monitoring wells ranged from 10,000 to 40,000 pCi/L this last year. In comparison, the concentrations of tritium in wells near the 216-A-37-1 Crib (see Figure 4.4-1) ranged from 100,000 to 1,000,000 pCi/L (Figure 4.4-9).

4.4.4.2 Statistical Evaluation. Statistical analyses establishing background conditions are required by 40 CFR 265.93(b) and WAC 173-303-400. Background information including raw data, replicate averages, and background summary statistics were provided in the 1992 annual report (DOE-RL 1993a). Appendix C of this document contains a description of the statistical methodology used to establish background values. The GTF was under an indicator parameter evaluation program, but with the status change to cold standby the monitoring program has been placed on hold.

Table 4.4-3 lists the critical mean values (or ranges) and upgradient/downgradient comparison values for the GTF indicator parameters, which were compared to the average parameter concentrations at the downgradient wells to determine if there was a significant statistical difference. The indicator parameters did not exceed the applicable critical means, except for SC at well 299-E25-33. Assessment monitoring was not initiated because no hazardous waste has been disposed to the vaults. Refer to Section 4.4.4.1.1 for a discussion of this historically elevated constituent, and also to Appendix A for information on recent laboratory audit findings and resultant limitations for TOX data.

4.4.5 Groundwater Flow

4.4.5.1 Groundwater Flow Direction. This year's water level data for GTF wells and wells in the vicinity of the GTF are available in RCRA quarterly reports (DOE-RL 1993b, 1993c, 1993d, 1993e). These wells are measured on at least a semiannual schedule and usually on a quarterly basis (see Table 4.4-1). Water level data identified as suspect data (in error) were flagged in the quarterly reports, and excluded from water level-related calculations.

Water levels were evaluated for vertical hydraulic gradients using the dual piezometer well 299-E25-32P and 299-E25-32Q. The "P" piezometer at this well is completed at the top of the uppermost unconfined aquifer; the "Q" piezometer is completed at the bottom of the uppermost aquifer. Since late 1991 the heads in the "P" and "Q" piezometers are separated by an average of 0.09 m (0.3 ft) (Figure 4.4-10). The higher head is in the "P" piezometer, implying that there is a downward flow component in the area of the upgradient well. This is not unexpected based on the proximity of well 299-E25-32 to the B Pond surface disposal facility. The B Pond recharges the uppermost aquifer and is the major control on groundwater flow direction at the GTF and the surrounding area. However, water level measurement and surveying error may be responsible for the head separation; although given the magnitude of separation, these errors may not be significant.

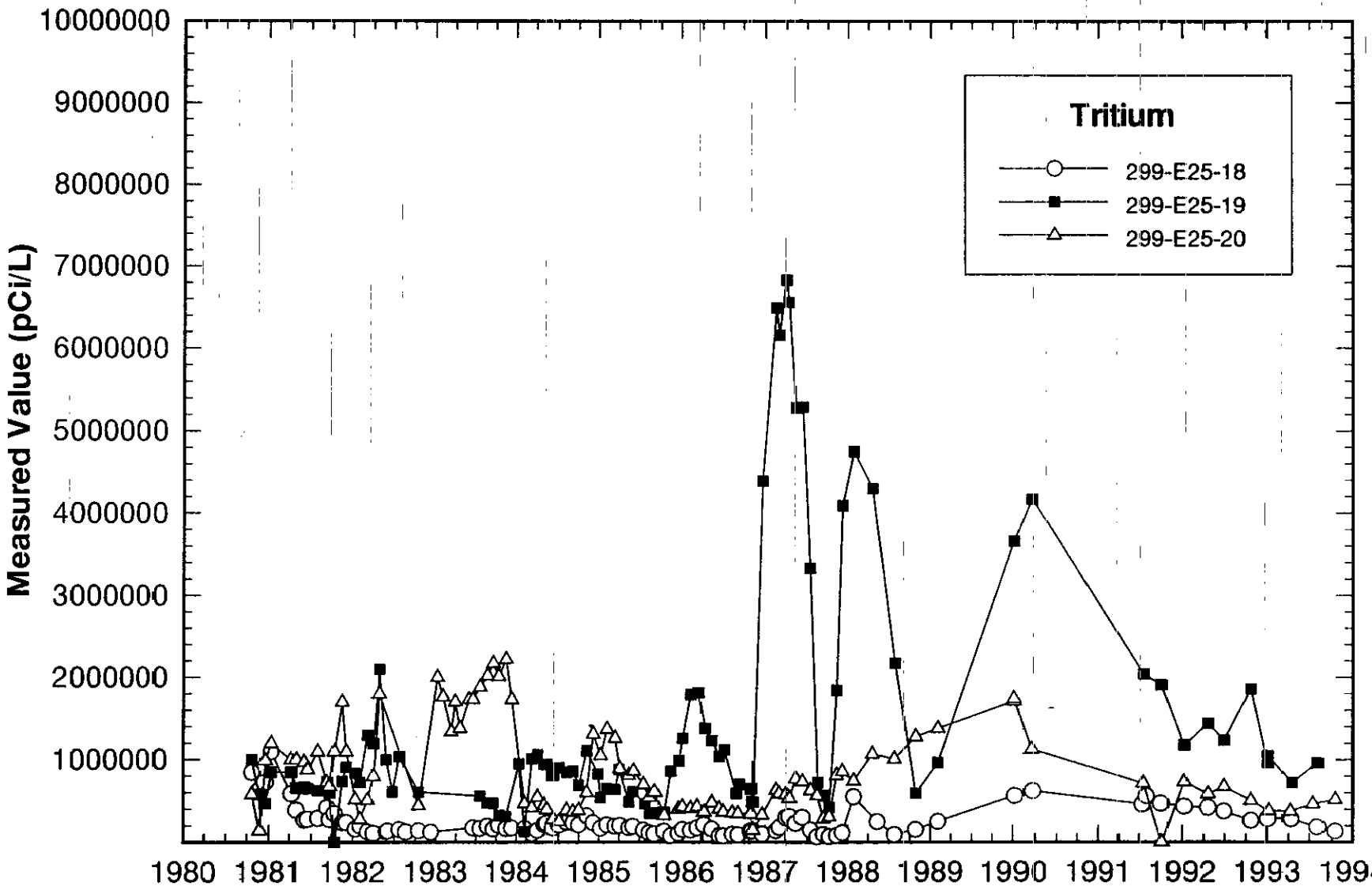


Figure 4.4-9. Concentration Plot for Tritium at 216-A-37-1 Crib Wells.

Table 4.4-3. Critical Means Table for 40 Comparisons--
Background Contamination Indicator Parameter Data
for the Grout Treatment Facility.[a,b]

Constituent (unit)	n	df	t_c	Average background	Standard deviation	Critical mean	Upgradient/ downgradient comparison value
Specific conductance (μmho/cm)	14	13	4.598	156.036	29.265	295.3	295.3
Field pH	14	13	4.984	8.213	0.311	[6.65, 9.82]	[6.65, 9.82]
Total organic carbon[c] (ppb)	15	14	4.500	721.1	223.735	1,760.8	1,760.8
Total organic halogen[c] (ppb)	8	7	6.082	6.338	3.201	27.0	NC[d]

[a]Data collected from August 1988 to June 1989 for upgradient wells 2-E25-25 and 2-E25-32P, and from June 1991 to June 1992 for the newly installed upgradient well 2-E25-39. Inconsistent replicate values from well 2-E25-39 (6/26/91) are not used in the calculation of background levels. Critical means calculated based on 40 comparisons.

[b]The following notations are used in this table:
df = degrees of freedom (n-1)
n = number of background replicate averages
t_c = Bonferroni critical t-value for appropriate df and 40 comparisons.

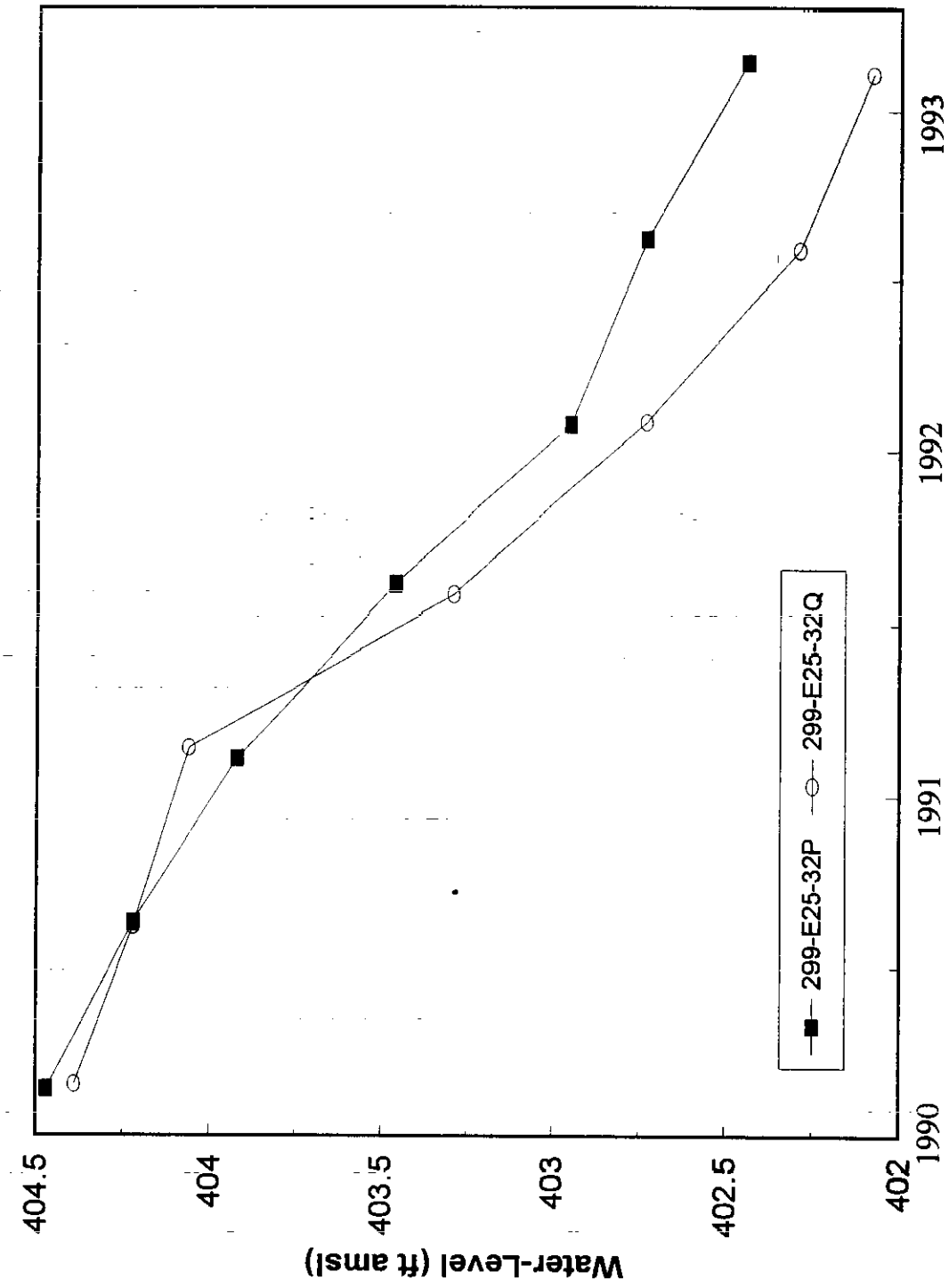
[c]Critical means were calculated using data analyzed by U.S. Testing, Inc., Richland, Washington.

[d]Upgradient/downgradient comparison value for total organic halogen cannot be established because problems associated with data quality preclude the determination of the total organic halogen limit of quantitation.
NC = not calculated.

Data from the downgradient piezometer, 299-E25-29, were not useful for ascertaining a vertical gradient in this area because of poor-quality water level measurements. Good measurements are difficult to collect at this piezometer because of its small diameter (5 cm [2 in.]), interference from the dedicated sampling pump, and condensation on the riser tubing wall.

Water level contours for the unconfined aquifer in the vicinity of the facility for June 1993 are shown in Figure 4.4-11. As noted in this figure, groundwater flows to the southwest across the site. Water levels and groundwater movement in the GTF vicinity also are discussed in Section 4.5,

Figure 4.4-10. A Comparison Between Water Levels in Upgradient Dual Piezometer Well 299-E25-32.



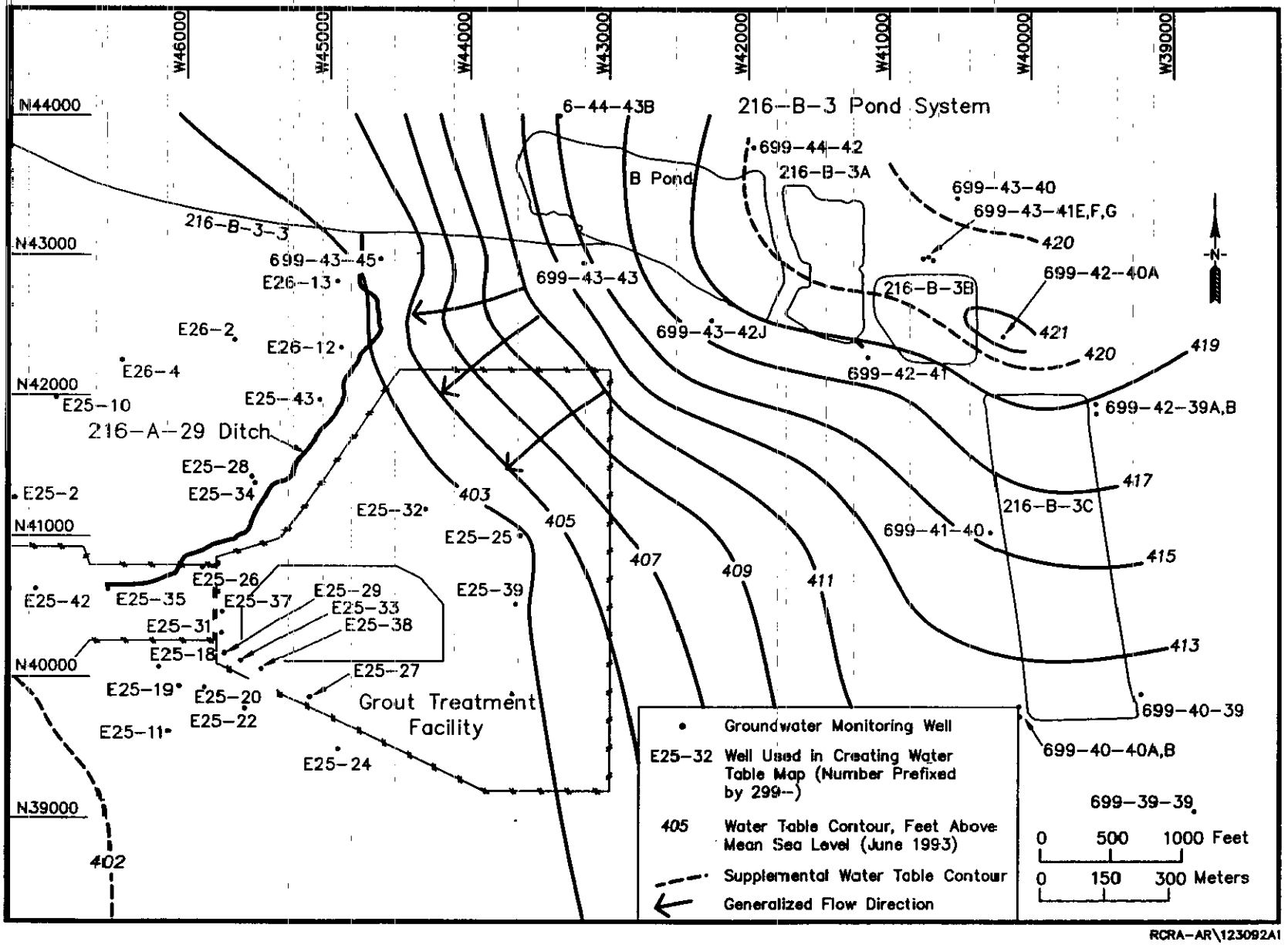


Figure 4.4-11. Groundwater Table Map for the Grout Treatment Facility and Vicinity, June 1993.

216-B-3 Pond System, and Section 4.6, 216-A-29 Ditch. Water levels declined from 0.15 to 0.2 m (0.5 to 0.75 ft) in the downgradient and upgradient wells (Figure 4.4-12), respectively (Figures 4.4-13 and 4.4-14). These changes are about the same as the water level changes last year. The water level decline is associated with decreasing discharges to B Pond, and represents a long-term trend.

4.4.5.2 Rate of Flow. Groundwater in the vicinity of the GTF is driven southwestward by the water table mound associated with B Pond. The mounding influences the hydraulic gradient in the area, and therefore the rate of groundwater movement. An estimate of the average linear groundwater flow rate can be calculated from a modification of Darcy's law using the following equation:

$$V = \frac{Ki}{n_e} \qquad (1)$$

where:

V = Average linear groundwater velocity (m/d)
K = Hydraulic conductivity (m/d)
i = Hydraulic gradient (m/m)
n_e = Effective porosity.

The following assumptions are made for the GTF area (DOE-RL 1992):

K = 304.8 m/d (1,000 ft/d)
n_e = 0.25.

Using June 1993 data, the water table gradient between GTF wells 299-E25-29P (downgradient) and 299-E25-32P (upgradient) was about 7.5×10^{-5}. The estimated calculated linear groundwater velocity using this information is about 0.09 m/d (0.3 ft/d). This velocity is about an order of magnitude less than the west-to-southwesterly movement of 0.6 to 0.9 m/d (2 to 3 ft/d) reported for the GTF in 1987 and 1988 (DOE-RL 1992), and is a function of the smaller hydraulic gradient across the site.

4.4.5.3 Evaluation of Monitoring Well Network. Three new downgradient monitoring wells, 299-E25-49, 299-E25-50, and 299-E25-1000, were added to the monitoring well network in 1993. A borehole completion data package will be issued in early 1994 for these three wells. The total number of monitoring wells in the network now stands at 13 wells: 9 downgradient and 4 upgradient. The new wells are spaced at about 114.3 m (375 ft) rather than the originally planned 76.2-m (250-ft) spacing. The wider spacing was used after technical discussions with Ecology. The addition of the three 1993 wells completes the planned GTF indicator monitoring well network as described in the dangerous waste permit application (DOE-RL 1992).

Figure 4.4-12. Water Levels in Select Upgradient Wells.

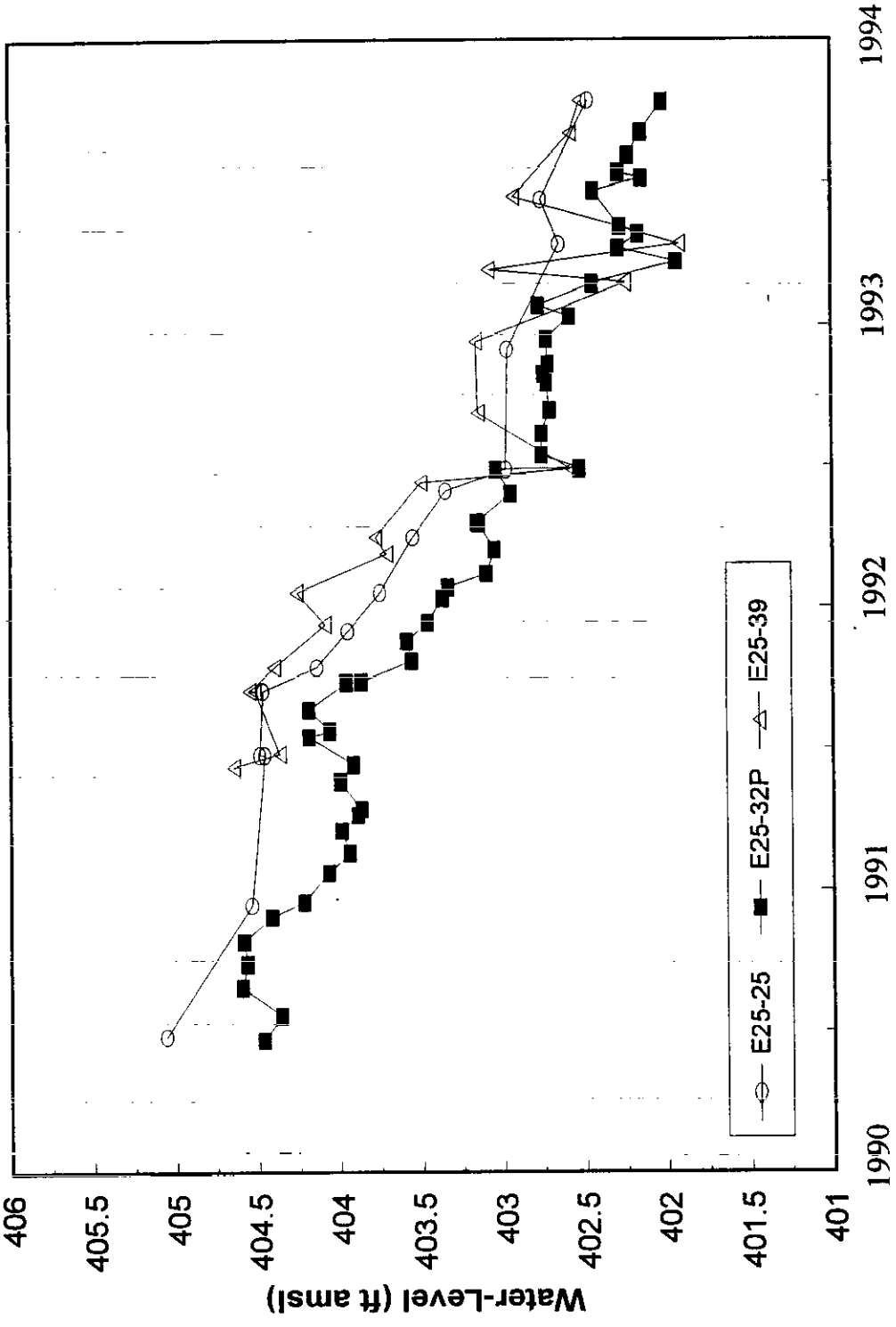


Figure 4.4-13. Hydrograph for Grout Treatment Facility Upgradient Monitoring Wells.

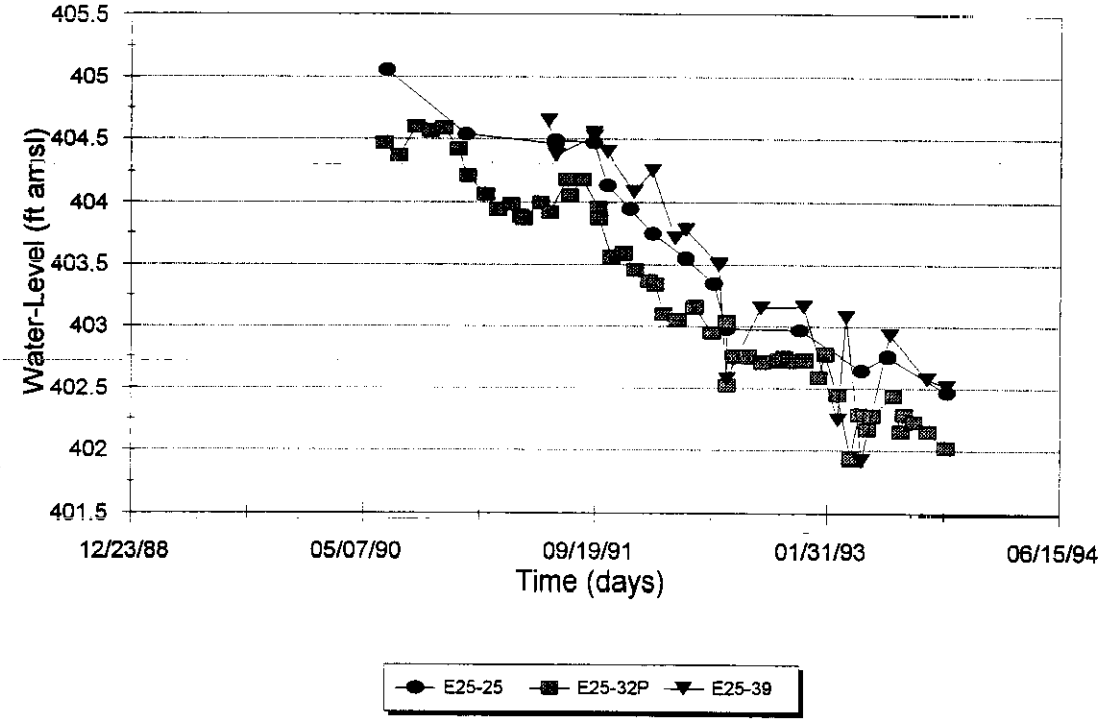
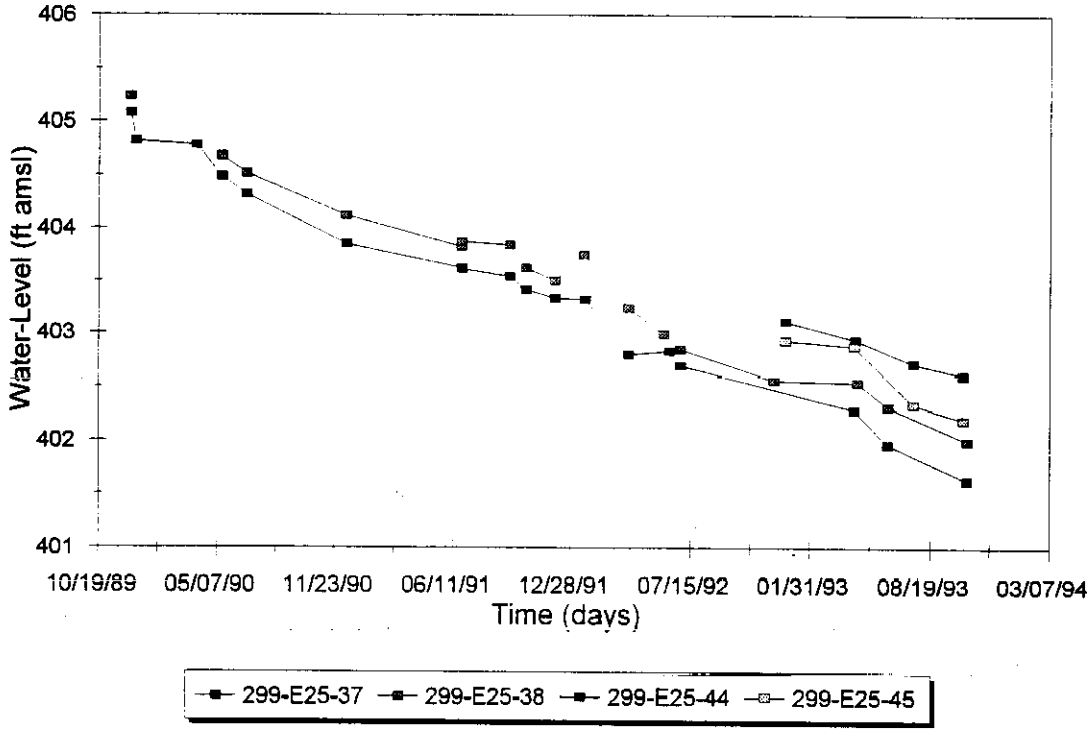


Figure 4.4-14. Hydrograph for Grout Treatment Facility Downgradient Monitoring Wells.



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WAC 173-303, "Dangerous Waste Regulations," *Washington Administrative Code*, as amended.

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4.5 216-B-3 POND SYSTEM

D. B. Barnett
Westinghouse Hanford Company

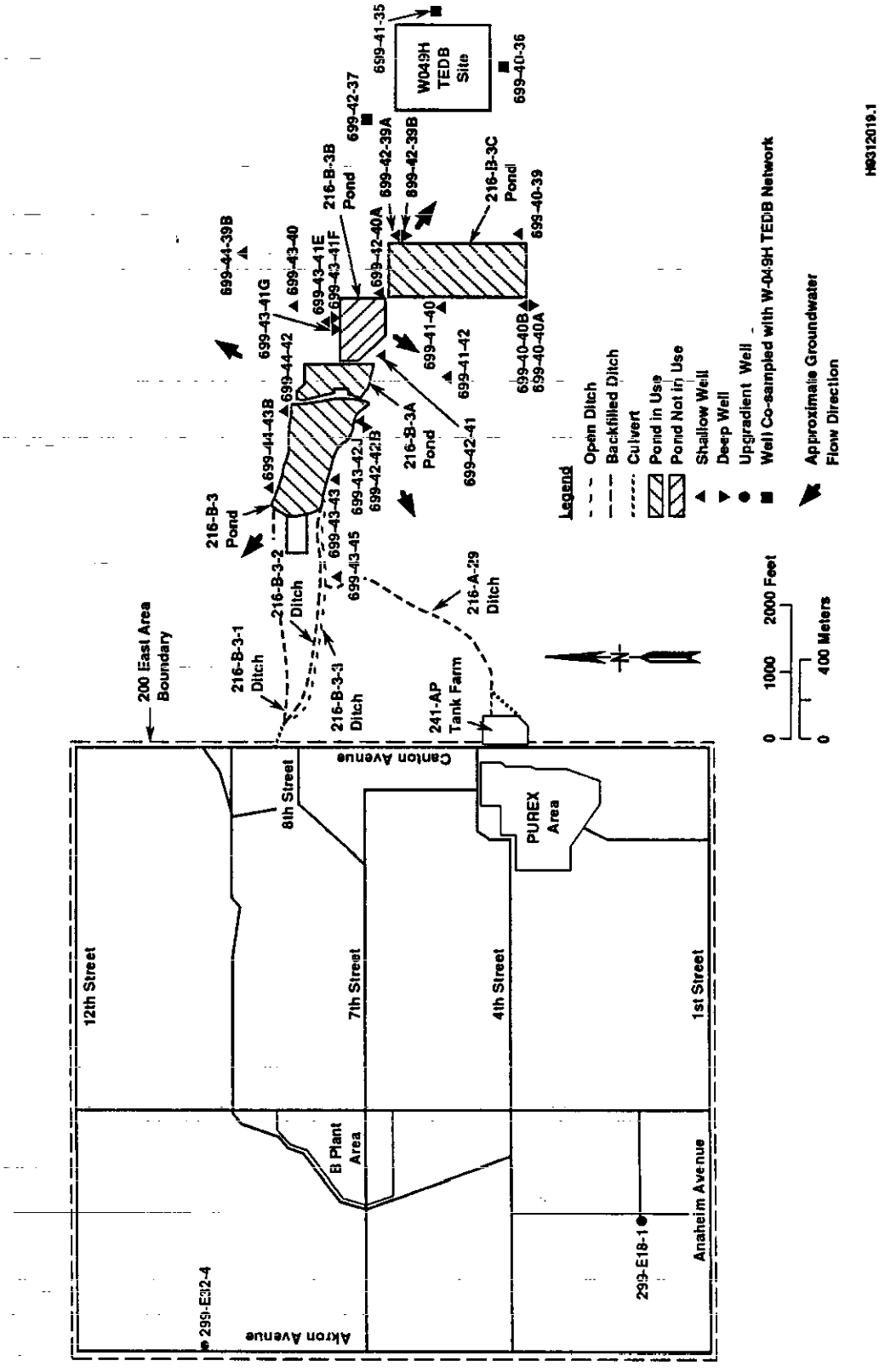
4.5.1 Facility Overview

This section summarizes information collected and analyzed in fiscal year (FY) 1993 to describe distribution and concentration of waste constituents in groundwater at the 216-B-3 Pond (B Pond) system. The 216-B-3 Pond system is a regulated waste water disposal facility for operations in the 200 East Area of the Hanford Site. Groundwater monitoring was elevated from a *Resource Conservation and Recovery Act of 1976* (RCRA) detection program to an assessment level program in 1990, and the *Ground Water Quality Assessment Plan for the 216-B-3 Pond System* (Harris 1990) was submitted to the Washington State Department of Ecology (Ecology). The assessment plan supplements activities discussed in the *Interim-Status Groundwater Monitoring Plan for the 216-B-3 Pond* (Luttrell et al. 1989) and the closure/post-closure plan (DOE-RL 1993a). The 216-B-3 Pond system is also part of the 200-BP-11 operable unit, which is regulated under the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) program.

The 216-B-3 Pond system is located east of the 200 East Area and consists of a main pond and three interconnected lobes for wastewater disposal as well as several ditches leading to the ponds (Figure 4.5-1). The main pond is located in a natural topographic depression, diked on the eastern margin, and currently covers approximately 14.2 ha (35 acres), with a maximum depth of about 6.1 m (20 ft). The 216-B-3 Pond began receiving liquid effluent in 1945. Three expansion ponds (3A, 3B, and 3C Ponds) were placed into service in 1983, 1984, and 1985, respectively. The 3A Pond and the 3B Pond are about 4.5 ha (11 acres) in size, and the 3C Pond is approximately 16.6 ha (41 acres). The 3B Pond currently is not in use. Water discharged to these ponds infiltrates into the ground and recharges the underlying aquifer.

The B Pond receives wastewater primarily from the Plutonium-Uranium Extraction (PUREX) Plant and B Plant. Specifically, these streams consist of B Plant cooling water, PUREX Plant chemical sewage via the PUREX cooling water line (rerouted from 216-A-29 Ditch), and PUREX Plant steam condensate, which may be sent to the B Pond system only if the stream is diverted to the 216-A-42 Diversion Basin. The B Plant steam condensate and chemical sewer were discharged to the B Pond system in the past. Additional sources of effluent to the B Pond system are the 242-A Evaporator (cooling water and steam condensate), 244-AR Vault (liquid effluent), 241-A-702 vessel ventilation system (cooling water), 283-E Water Treatment Facility (filter backwash), and the 284-E Powerhouse (liquid effluent). Potential contaminants contained within past waste streams, which may have entered the groundwater, are discussed in DOE-RL (1993a). During 1993, the volume of effluent discharged to the B Pond system averaged approximately 13,000 L/min (3,400 gal/min) or 19 million L/day (5 million gal/day).

Figure 4.5-1. Monitoring Well Locations for the 216-B-3 Pond.



RCRA groundwater monitoring for the B Pond system began in 1988 with a detection program and was elevated to an assessment level program following review of the analytical chemistry results from the first and second quarters of 1990. Concentrations of total organic halogen (TOX) were above the allowable background concentrations in two of the B Pond wells (see Section 4.5.5). The *Ground Water Quality Assessment Plan for the 216-B-3 Pond System* (Harris 1990) was prepared and submitted to Ecology in May 1990.

4.5.2 Summary of 1993 RCRA Activities

The 216-B-3 Pond system continued in a groundwater quality assessment monitoring program during 1993. Wells in the network were sampled during October, January, and April for the first three quarters of FY 1993, and during July and August for the final quarter, except three wells shared with the W-049H Treated Effluent Disposal Basin (TEDB). These three wells were sampled during December, February, May, and August during FY 1993.

To meet *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) Milestone M-24-27 (Ecology et al. 1992) and the requirements of the *Ground Water Quality Assessment Plan for the 216-B-3 Pond System* (Harris 1990), two wells constructed during late FY 1992/early FY 1993 were sampled for the first time in January 1993. Both wells were constructed to monitor the upper portion of the uppermost aquifer. In addition, the three wells shared by B Pond and W-049H TEDB networks were sampled for the first time in December 1992. These wells also monitor the uppermost aquifer.

During 1993, the RCRA Part A permit application was modified to distinguish the three expansion ponds (3A, 3B, and 3C) from the main pond and the 216-B-3-3 Ditch. This change will allow clean closure of the expansion ponds and integration of the main pond with RCRA corrective action for the 200-BP-11 operable unit (DOE-RL 1993a). Interim stabilization activities for the main pond are scheduled to begin in April 1994.

4.5.3 Other Activities in 1993

4.5.3.1 W-049H TEDB. As mandated by Tri-Party Agreement Milestone 17-08, the W-049H Project was undertaken to provide a disposal facility for treated liquid effluent from the 200 Areas generating facilities. Pending the securing of appropriate permits, the disposal facility will allow infiltration of treated (cleaned) liquid effluent to the soil column. Site hydrogeologic characterization occurred during FY 1992 and FY 1993. The work included drilling of three RCRA-standard monitoring wells, aquifer testing, soils and groundwater chemistry evaluation, and stratigraphic/structural analysis of the suprabasalt formations (Davis et al. 1993).

Because of its proximity to the B Pond system, the site characterization of the W-049H TEDB also enhances knowledge of B Pond hydrogeology and groundwater chemistry. The W-049H TEDB and its three monitoring wells are immediately downgradient hydraulically from the B Pond system. These wells will remain a part of the B Pond groundwater monitoring network at least through FY 1994.

4.5.3.2 Aquifer Testing. To more accurately define hydraulic properties of the unconfined aquifer, Pacific Northwest Laboratory conducted a pumping test and other hydraulic testing near the main lobe of the B Pond system during the summer of 1993. Well 699-42-42B was pumped for 24 hours at a constant rate. Slug-interference and sinusoidal-pulse tests were also conducted in this well. Well 699-43-42J and a nearby group of nested piezometers were the observation wells during the tests. Results of the pumping test are presented in Thorne et al. (1993). Results of the other tests will be available in 1994.

4.5.4 Sampling and Analysis Program

The monitoring well network for the B Pond system consists of 2 upgradient monitoring wells and 23 downgradient monitoring wells, shown in Figure 4.5-1 and listed in Table 4.5-1. The monitoring program is described in the groundwater monitoring plan (Luttrell et al. 1989). With one exception, all of the downgradient wells in the network meet RCRA construction standards and were installed during the period 1988 through 1992. Well 699-42-40A was installed in 1981 and has a stainless steel screen, but the seal does not strictly meet RCRA guidelines. Judging from its history of analytical results, the sample worthiness of this well appears uncompromised by its pre-RCRA construction.

The upgradient wells, in the western portion of the 200 East Area, were constructed in 1987 and 1988. The upgradient wells and most of the downgradient wells were constructed to monitor the top 4.6 m (15 ft) of the uppermost aquifer. Five of the downgradient wells (699-40-40A, 699-42-39B, 699-42-42B, 699-43-41F, and 699-43-41G) are screened to monitor a lower horizon within the uppermost aquifer, approximately 7.6 to 15.2 m (25 to 50 ft) below the top of the saturated zone. Well 699-40-40A is paired with wells 699-40-40B, 699-42-39A with 699-42-39B, and 699-43-42J with 699-42-42B, forming three shallow and deeper well clusters. Wells 699-43-41E, 699-43-41F, and 699-43-41G are grouped together to form a shallow, intermediate, and deep well cluster.

The three wells around the W-049H TEDB are monitored to extend coverage of the B Pond network to the east. These wells monitor the upper portion of the uppermost aquifer, which is essentially confined at these locations. All three wells are screened within the Ringold Formation unit A, just below the Ringold lower mud sequence (refer to Section 4.1).

In addition to the wells belonging to the RCRA and W-049H TEDB monitoring networks, other wells in the area around the B Pond are periodically used to measure water levels.

All 25 of the monitoring wells meet the regulatory criteria for location downgradient from the facility because of radial flow away from the pond system induced by groundwater mounding (see Section 4.5.6). Because of this condition, no upgradient well, in the strict sense, can be placed within the vicinity of the B Pond facility. The possible placement of additional monitoring wells under the assessment program will be addressed in future reports or revisions to the groundwater monitoring plan.

Table 4.5-1. Monitoring Wells Used for the 216-B-3 Pond System.
(sheet 1 of 2)

Well	Aquifer	Sampling frequency	Water levels	Well standards	Other networks
299-E18-1[88]	Top of unconfined	SA	M	RCRA	2101-M
299-E32-4[87]	Top of unconfined	SA	M	RCRA	LLWMA-2
699-40-36[92]	Top of confined	Q	M	RCRA	W-049H
699-40-39[89]	Top of semiconfined	Q	M	RCRA	--
699-40-40A[91]	Lower semiconfined	Q	M	RCRA	--
699-40-40B[91]	Top of semiconfined	Q	M	RCRA	--
699-41-35[92]	Top of confined	Q	M	RCRA	W-049H
699-41-40[89]	Top of semiconfined	Q	M	RCRA	--
699-41-42[92]	Top of unconfined	Q	M	RCRA	--
699-42-37[92]	Top of confined	Q	M	RCRA	W-049H
699-42-39A[91]	Top of semiconfined	Q	M	RCRA	--
699-42-39B[91]	Lower semiconfined	Q	M	RCRA	--
699-42-40A[81]	Top of semiconfined	SA	M	PRE	--
699-42-41[91]	Top of unconfined	Q	M	RCRA	--
699-42-42B[88]	Top of unconfined	SA	M	RCRA	--
699-43-40[91]	Top of unconfined	Q	M	RCRA	--
699-43-41E[89]	Top of semiconfined	Q	M	RCRA	--
699-43-41F[89]	Lower semiconfined	Q	M	RCRA	--
699-43-41G[91]	Top of lower semiconfined	Q	M	RCRA	--
699-43-42J[88]	Lower unconfined	SA	M	RCRA	--
699-43-43[88]	Top of unconfined	Q	M	RCRA	A-29
699-43-45[89]	Top of unconfined	Q	M	RCRA	A-29
699-44-39B[92]	Top of semiconfined	Q	M	RCRA	--

Table 4.5-1. Monitoring Wells Used for the 216-B-3 Pond System. (sheet 2 of 2)

Well	Aquifer	Sampling frequency	Water levels	Well standards	Other networks
699-44-42[88]	Top of unconfined	SA	M	RCRA	--
699-44-43B[89]	Top of unconfined	Q	M	RCRA	--

Notes: Shading denotes upgradient wells. Superscript following well number denotes the year of installation.
M = frequency on a monthly basis.
PRE = well was constructed before RCRA-specified standards.
Q = frequency on a quarterly basis.
RCRA = well is constructed to RCRA-specified standards.
SA = frequency on a semiannual basis.

This year, four quarters of sampling were completed at B Pond. Because of the elevated TOX and total organic carbon (TOC) detected in several wells in 1991 (699-43-41E, 699-43-41F, 699-42-40A, and 699-43-42J), several additional parameters were sampled in 1992 and 1993 in all the downgradient wells (see "Assessment Monitoring Parameters" in Table 4.5-2). These analyses were chosen to identify the particular chemical species causing the elevated TOX and TOC values. Analytical results of the groundwater sampling for B Pond are presented in quarterly reports (DOE-RL 1993b, 1993c, 1993d, 1994).

Wells installed for the B Pond network in 1992 were first sampled during the first or second quarter of 1993. By August 1993, the first full year of quarterly sampling had been completed for wells shared with the W-049H TEDB. The first year of sampling in these wells included contamination-indicator parameters, groundwater quality constituents, drinking water constituents, site-specific constituents, assessment monitoring parameters, and the Appendix IX (40 CFR 264) list of constituents. All other downgradient wells were sampled on a quarterly or semiannual schedule for these same constituents except the Appendix IX list. All wells in the network have now been sampled at least once for the Appendix IX constituents. Upgradient wells were sampled on a semiannual schedule for contamination-indicator parameters and groundwater quality parameters. The entire list of constituents sought at B Pond is given in Table 4.5-2.

4.5.5 Groundwater Chemistry

4.5.5.1 Concentration Histories of Waste Indicators. Chemistry data for the groundwater contamination indicator parameters (TOX, TOC, pH, and specific conductance) from the two upgradient wells for B Pond have been used to establish background concentration limits not to be exceeded in the downgradient wells. The B Pond system was elevated to assessment level monitoring in 1990 because of elevated concentrations of TOX in downgradient well 699-43-41E. During 1990, well 699-43-41F also exhibited high concentrations of TOX and TOC.

Table 4.5-2. 216-B-3 Pond, Chemical Constituent List.

Contamination indicator parameters		
pH	Total organic carbon	
Specific conductance	Total organic halogens	
Groundwater quality parameters		
Chloride	Manganese	Sodium
Iron	Phenols	Sulfate
Drinking water parameters		
2,4-D	Fluoride	Nitrate
2,4,5-TP	Gross alpha	Radium
Arsenic	Gross beta	Selenium
Barium	Lead	Silver
Chromium	Lindane	Silvex cadmium
Coliform bacteria	Mercury	Toxaphene
Endrin	Methoxychlor	Turbidity
Site-specific parameters		
Ammonium	Hydrazine	Tritium
Assessment monitoring parameters		
Anions	Polychlorinated biphenyls	
Herbicides	Volatile, semi-volatile organic compounds	
Pesticides		

4.5.5.1.1 TOX. In 1991, TOX in wells 699-43-41E and 699-43-41F continued to be above established background limits. However, because of recent laboratory audit findings, 1992 and 1993 TOX data are determined unusable. Therefore, specific TOX results are not discussed here (see discussion in Appendix A).

Attempts to isolate a specific constituent(s) that may account for elevated TOX results have been unsuccessful to date. Analyses for the assessment monitoring parameters (see Table 4.5-2) and/or Appendix IX (40 CFR 264) list of constituents, in all 23 downgradient wells, have revealed no species that correlate with the observed 1990 TOX values that placed the facility into assessment status.

During the April through June 1993 sampling period a result for tris-2-chloroethyl phosphate of 44 ppb was reported for well 699-40-40A. This constituent was detected again in the July through September 1993 period in this same well (21 ppb); and four other wells: 699-40-40B (14 ppb), 699-40-36 (18 ppb), 699-41-35 (25 ppb), and 699-42-37 (18 ppb). Potential connections

between this compound and elevated TOX in the B Pond network are presently being investigated. It is unlikely that any definitive correlation can be made until a reliable database of TOX results can be reestablished.

4.5.5.1.2 TOC. All results for TOC fell below the contractually required quantitation limit (CRQL) (1,000 ppb) in 1993. In fact, TOC results have been at or below the CRQL for all wells in the network since early 1992. Results of TOC below CRQL have been reported only since the second quarter of 1993. Accordingly, no meaningful trends in TOC are yet apparent.

4.5.5.1.3 Specific Conductance. During 1993, trends in specific conductance were either slightly downward or unchanged for all wells in the B Pond network, except well 699-40-36. Specific conductance in well 699-40-36 appears to be increasing slightly, but steadily, from an average of 310 to 330 μmho/cm. Specific conductance values range from averages of 141 μmho/cm in well 699-42-40A, during the first quarter of 1993; to 555 μmho/cm in upgradient well 299-E18-1, also during the first quarter of 1993.

4.5.5.1.4 pH. Downgradient well 699-42-40A produced the lowest apparent field pH result in the network (6.10) during the April through June period of 1993. This result falls below the drinking water standard (DWS) lower limit for pH (Table 4.5-3), but its validity is suspect because it is much lower than a laboratory pH measurement for the same sample. The highest pH result (8.78, in a field measurement) occurred during the January through March 1993 period in well 699-43-41E. This value and five others (see Table 4.5-3) exceed the upper limit of DWS for pH.

4.5.5.1.5 Site-Specific Constituents. The DWS for tritium was exceeded at least one time each in 10 of the 23 downgradient wells at the B Pond system. The maximum activity measured was 169,000 pCi/L in well 699-41-40. Figure 4.5-2 illustrates the trend since 1990, for the five wells having highest tritium activity in the B Pond system groundwater monitoring network. Trends in these wells typify the general trend of decline for tritium in the network (see Section 4.5.5.2). Well 699-42-40C, which monitors the Rattlesnake Ridge interbed aquifer (see Section 4.1) between B and C Ponds, has shown an eight-fold increase in tritium since 1987. The maximum result for tritium in this well (8,000 pCi/L) is still far below DWS. It is possible that tritium is migrating downward at this site from the uppermost aquifer to the Rattlesnake Ridge interbed aquifer. The vertical component of hydraulic gradient is distinctly downward here (see Section 4.5.6.1), and nearby wells in the uppermost aquifer produce high results for tritium (Figure 4.5-3).

Except for tritium, the only other constituents known to be of site-specific concern are TOC (discussed above), ammonium ion, and hydrazine. The ammonium ion was reported at very low levels of concentration in 1993; twice at the CRQL of 100 ppb in well 699-42-39B, and once at 100 ppb in well 699-43-43. Hydrazine was not reported above the CRQL (30 ppb) in any wells in the network during 1993.

4.5.5.1.6 Other Constituents. Additional drinking water and groundwater quality parameters are measured at all downgradient wells for comparison with established DWSs, as required by 40 CFR 265.92. Table 4.5-3 lists those constituents that exceeded DWSs during 1993, by well and quarter.

Table 4.5-3. Wells With Constituents Exceeding Drinking Water Standards by Quarter, Fiscal Year 1993.

Constituent	DWS	Wells Exceeding DWS by Quarter[1]			
		Oct.-Dec. 1992	Jan.-March 1993	April-June 1993	July-Sept. 1993
Chromium (unfiltered samples)	100 ppb	299-E18-1, 40-40B, 42-39A, 42-39B, 43-45	40-39, 40-40B, 41-40, 42-39A, 42-39B, 43-41E	42-37, 43-43	40-39, 40-40A, 41-40, 42-39A, 42-42B, 43-42J
Coliform	1 COL[2]	40-40B	40-40A, 40-40B	NE	44-39B
Iron (unfiltered samples)	300 ppb	All wells in the network except 41-35, 43-41G	40-36, 40-39, 40-40A, 40-40B, 41-40, 42-37, 42-39A, 42-39B, 42-40A, 43-40, 43-41E, 43-42J, 43-45, 44-43B	299-E18-1, 299-E32-4, 40-36, 40-40A, 40-40B, 41-42, 42-37, 42-39A, 43-43, 43-45	All wells in the network except 41-35, 43-41E, 43-43, 44-43B
Iron (filtered samples)	300 ppb	42-39B	NE	NE	44-42
Manganese (unfiltered samples)	50 ppb	All wells in the network except 43-43, 43-45	40-36, 40-39, 40-40A, 42-40A 40-40B, 41-35, 42-37, 42-39B, 42-40A, 43-40, 43-41G, 44-43B	299-E18-1, 40-36, 40-40A, 40-40B, 41-35, 42-37, 42-39B, 43-41G	40-39, 40-40A, 40-40B, 42-39B, 42-40A, 43-41G
Manganese (filtered samples)	50 ppb	40-36, 40-40A, 40-40B, 41-35, 42-37, 42-39B, 43-41G	40-36, 40-40A, 40-40B, 41-35, 42-37, 42-39B, 42-40A, 43-40, 43-41G, 44-43B	299-E18-1, 40-36, 40-40A, 40-40B, 41-35, 42-37, 42-39B, 43-41G	40-40A, 40-40B, 42-39B, 43-41G
Nitrate	45 ppm	43-43	NE	NE	NE
Tritium	2.0 E4 pCi/L	42-39A, 42-39B, 43-41G	41-40, 42-39A, 42-39B, 42-42B, 43-40, 43-41E, 43-41F, 43-41G, 44-43B	41-42, 42-39A, 42-39B, 43-41G	41-40, 41-42, 42-39A, 42-39B, 42-42B, 43-40, 43-41E, 43-41F, 43-41G
Turbidity	1 NTU	299-E18-1, 40-40A, 40-40B, 42-39A	40-40B, 41-40, 42-39A	299-E18-1, 40-36, 40-40B, 41-35, 41-42, 42-37, 42-39A	All wells in the network except 42-41, 43-43, 44-42
pH < 6.5	6.5	NE	NE	42-40A	NE
pH > 8.5	8.5	40-39, 41-40, 43-41E, 43-41G	43-41E, 43-41G	43-41E	NE

[1]All well designations prefixed by 699-, unless indicated otherwise.
[2]Coliform colonies per 100 milliliters.
DWS = drinking water standards.
NE = constituent did not exceed DWS in any wells during this quarter.
NTU = nephelometric turbidity unit.

Figure 4.5-2. Time-Versus-Concentration Plot of Tritium, 216-B-3 Pond. (This figure shows the five wells with highest tritium and trends since 1990.)

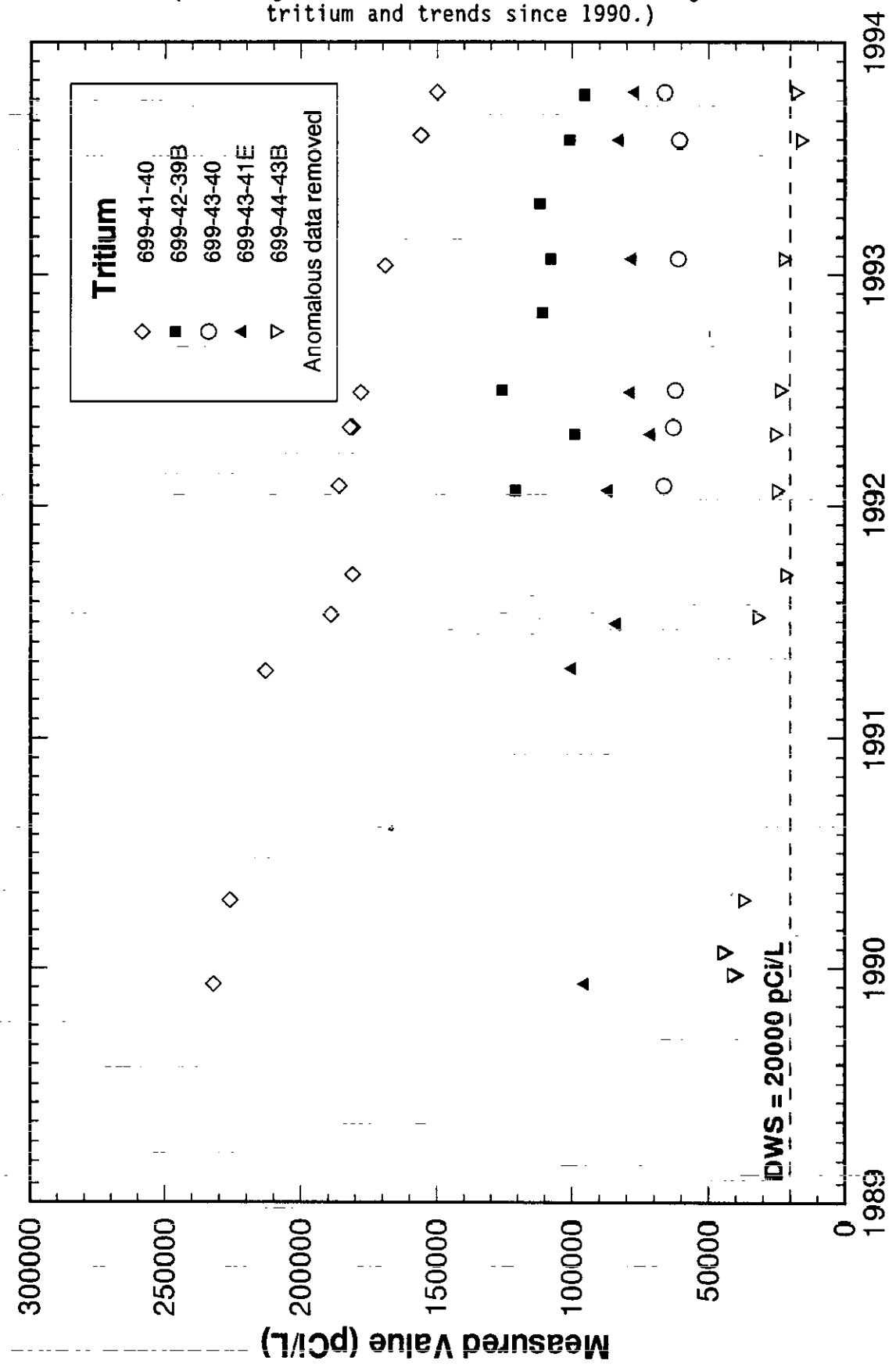
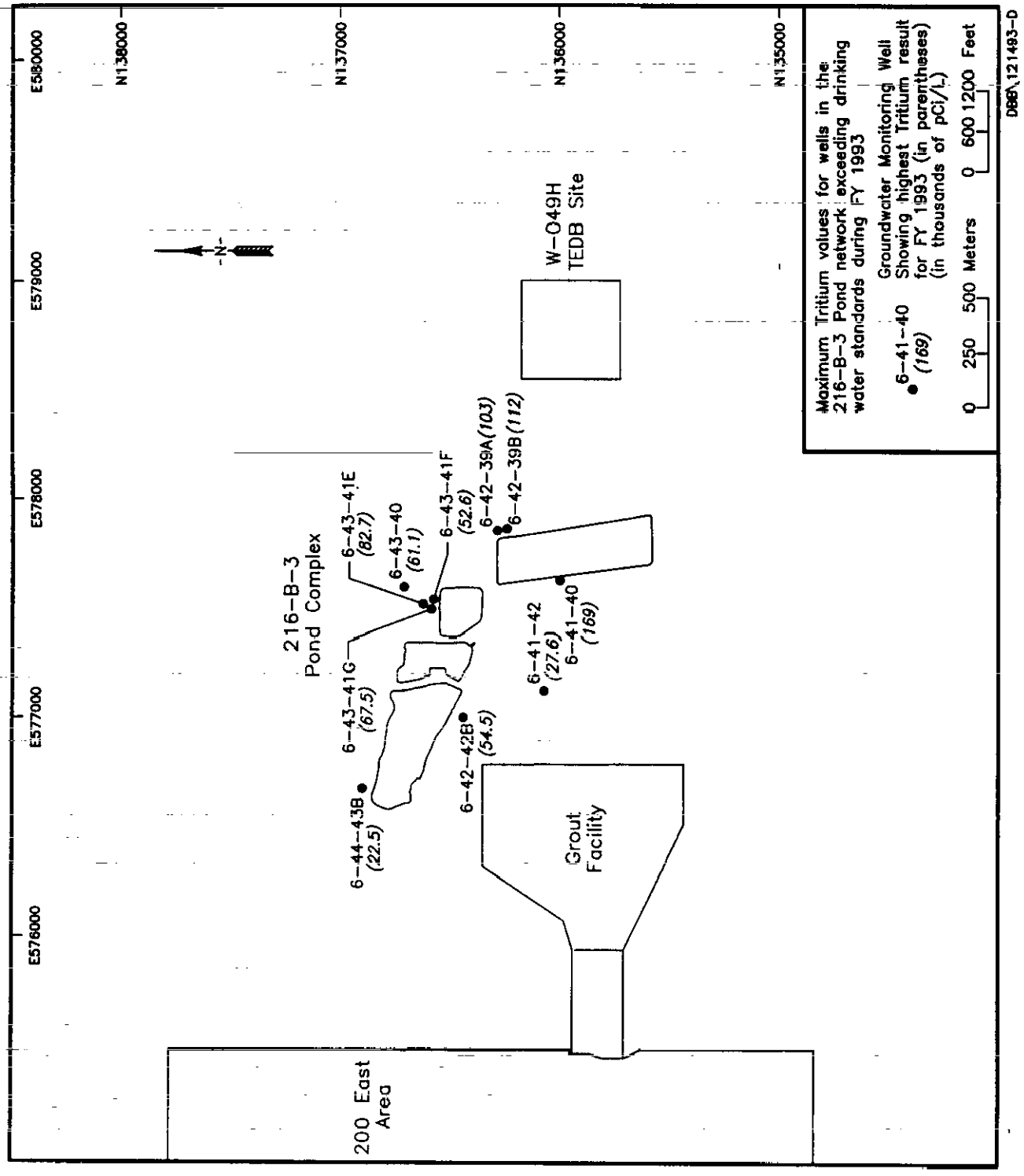


Figure 4.5-3. Maximum Results for Tritium During Fiscal Year 1993, 216-B-3 Pond. (This figure will show all wells that exceeded the DWS during the period and maximum value for that well.)



Chromium in unfiltered samples, iron in unfiltered samples, and manganese in filtered and unfiltered samples were the most common constituents exceeding DWSs in the B Pond system wells (see discussion in Section 2.2.4). The DWS for chromium is 100 ppb, though it is listed and discussed in terms of the superseded standard of 50 ppb in the first three quarterly RCRA groundwater reports for 1993 (DOE-RL 1993b, 1993c, 1993d).

Coliform bacteria were reported above DWS in three wells during 1993, though all of these occurrences are under investigation (Request for Analytical Data Evaluation [RADE]).

Nitrate was reported above the CRQL only once during 1993, but this value is suspect and is also the subject of a RADE.

Radium has apparently increased by 2 orders of magnitude in well 699-42-40A since 1990. However, the level activity of radium in this well remains extremely low (1.5 pCi/L).

Although the turbidity DWS officially applies only to surface water analyses (40 CFR 265), this property is monitored in groundwater to provide insight to occurrences of other constituents. During the July through September 1993 period, several constituents, notably unfiltered metals, in well 699-42-40A departed significantly from historical trends. This occurrence is tentatively linked to excessive turbidity (555 NTUs) reported for the same sample. Turbidity generally increased during 1993 in samples from nearly all wells in the B Pond system network. The reasons for this increase are most likely the declining water levels in many wells and/or excessive pumping rates during purging and sampling. Efforts are underway to optimize pumping rates.

4.5.5.1.7 RADE. RADEs are submitted for analytical results that depart from historical trends, or that otherwise differ from values reasonably expected for a particular constituent. Westinghouse Hanford Company's (WHC) analytical staff work to resolve these anomalies and recommend courses of action to project personnel. During 1993, RADEs were submitted for a total of 52 results of groundwater analyses from the 216-B-3 Pond system. Some of these RADEs involve constituents cited in Table 4.5-3 (DOE-RL 1993b, 1993c, 1993d, and 1994). Resolution is pending for all 1993 B Pond system RADEs.

4.5.5.2 Distribution of Waste Constituents. Groundwater beneath the B Pond system contains elevated levels of tritium from past wastewater disposal to the system. The areal distribution of tritium in groundwater at the B Pond system is illustrated in Figures 4.1-33 and 4.5-3. Figure 4.5-3 shows maximum values for tritium results during 1993 in all wells with at least one result above the DWS (20,000 pCi/L). Monitoring wells that have been in place around the B Pond system for several years show a consistent decline in tritium activities since the mid-1970's. The observed decline of tritium activities is likely a result of the dilution of older, more contaminated water by recent tritium-free effluent, and decay of the tritium radionuclide (half-life = 12.3 years).

4.5.6 Groundwater Flow

The sediments of the Ringold Formation comprise the bulk of the uppermost aquifer beneath the B Pond system. Specifically, groundwater flows within the unit A gravel sequence, lower mud sequence of the Ringold Formation, and somewhat within the lower gravels of the overlying Hanford formation immediately below the B Pond system. Section 4.1 discusses stratigraphy and hydrogeology in the vicinity of the B Pond system and the 200 East Area. Hydrogeology of the B Pond system is discussed more specifically in Davis et al. (1993) and DOE-RL (1993a).

During 1993, water table elevations were measured at least quarterly in all wells in the monitoring network, and monthly for most wells as part of the groundwater assessment program.

4.5.6.1 Groundwater Flow Direction. Groundwater flow in the B Pond area is dominated by the groundwater mound created by large volumes of wastewater recharging the uppermost aquifer (Figure 4.5-4). This hydraulic feature has altered the original groundwater flow pattern of the area. In the past, the mound was even more extensive because of larger volumes of effluent discharge to the system than at present (see Section 4.5.1). As the rate of effluent discharge decreases, water levels in wells within the influence of the mound generally are decreasing with time.

The horizontal component of groundwater flow at the B Pond system is radially outward from the center of the groundwater mound. Horizontal head gradient, as determined by water level measurement, is estimated at 0.001 to 0.008 in the region of the B Pond system during June 1993.

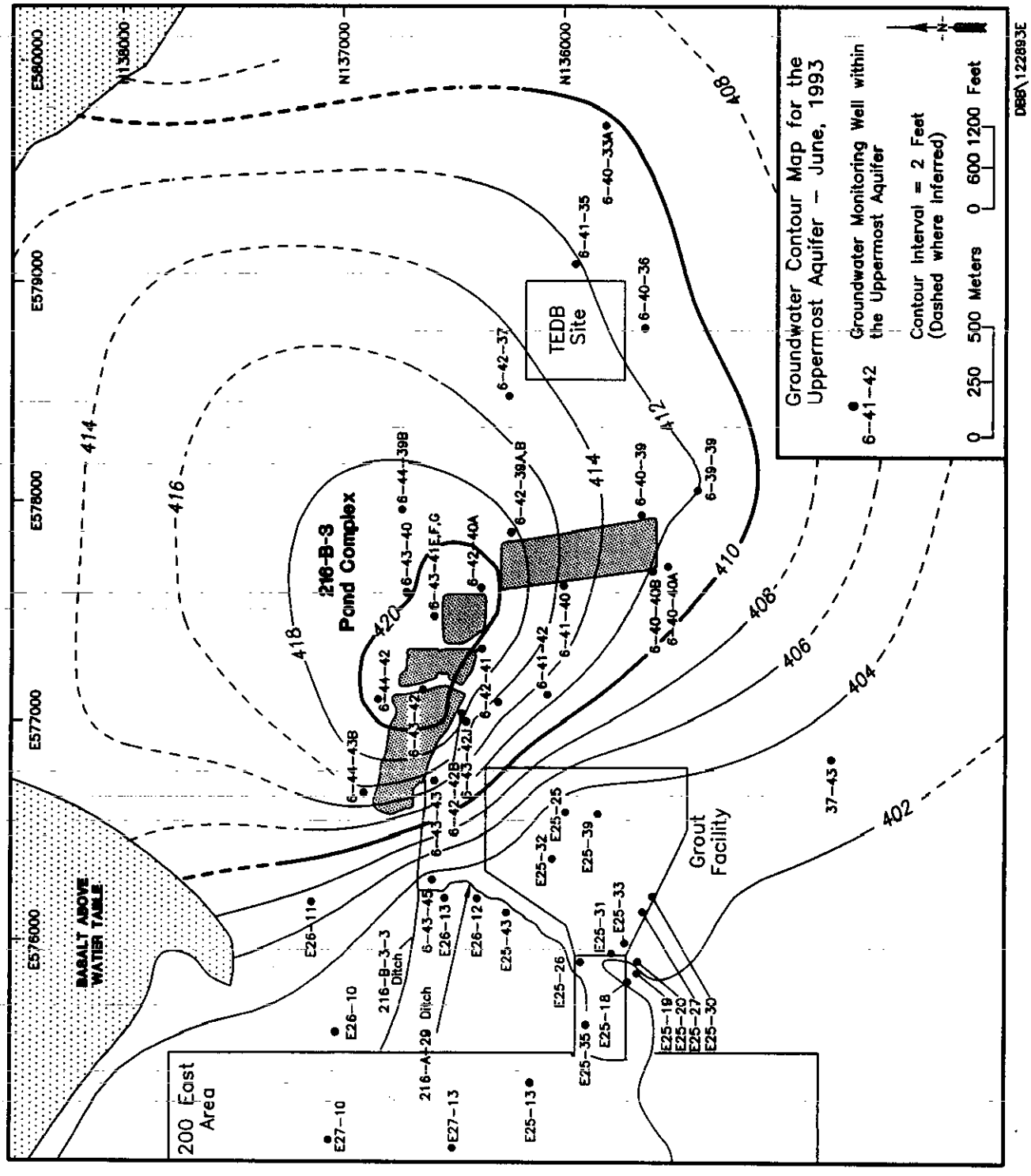
Vertical head gradients are estimated from four shallow/deep well pairs; 699-43-42J/42B, 699-40-40A/40B, 699-42-39A/39B, and 699-43-41E/41G (see Figure 4.5-1). Expectedly, vertical hydraulic gradients at these locations were directed downward. For static head measurements taken in June 1993, vertical hydraulic gradients ranged from 0.007 to 0.08, roughly 10 times the estimated horizontal component of head gradient.

4.5.6.2 Rate of Groundwater Flow. Early estimates of groundwater flow at the B Pond system were based on the migration of tritium from the 1960's to 1982 (Wilbur et al. 1983). Average horizontal groundwater flow velocity was estimated at 3 to 4 m/d (10 to 13 ft/d) by this method.

Other estimates of horizontal-component flow velocity are calculated by the relationship;

$$v = \frac{KI}{n} \qquad (1)$$

Figure 4.5-4. Potentiometric Surface Map of the 216-B-3 Pond and Vicinity, June 1993.



where:

v = Average linear groundwater velocity
K = Hydraulic conductivity
I = Head gradient (horizontal)
n = Effective porosity.

For the B Pond system: K is approximated at 640 m/d (2,100 ft/d) for the Hanford formation, and 1.5 m/d (5 ft/day) for the Ringold Formation; effective porosity ranges were from 0.1 to 0.3 for both the Hanford and the Ringold Formations (WHC 1990).

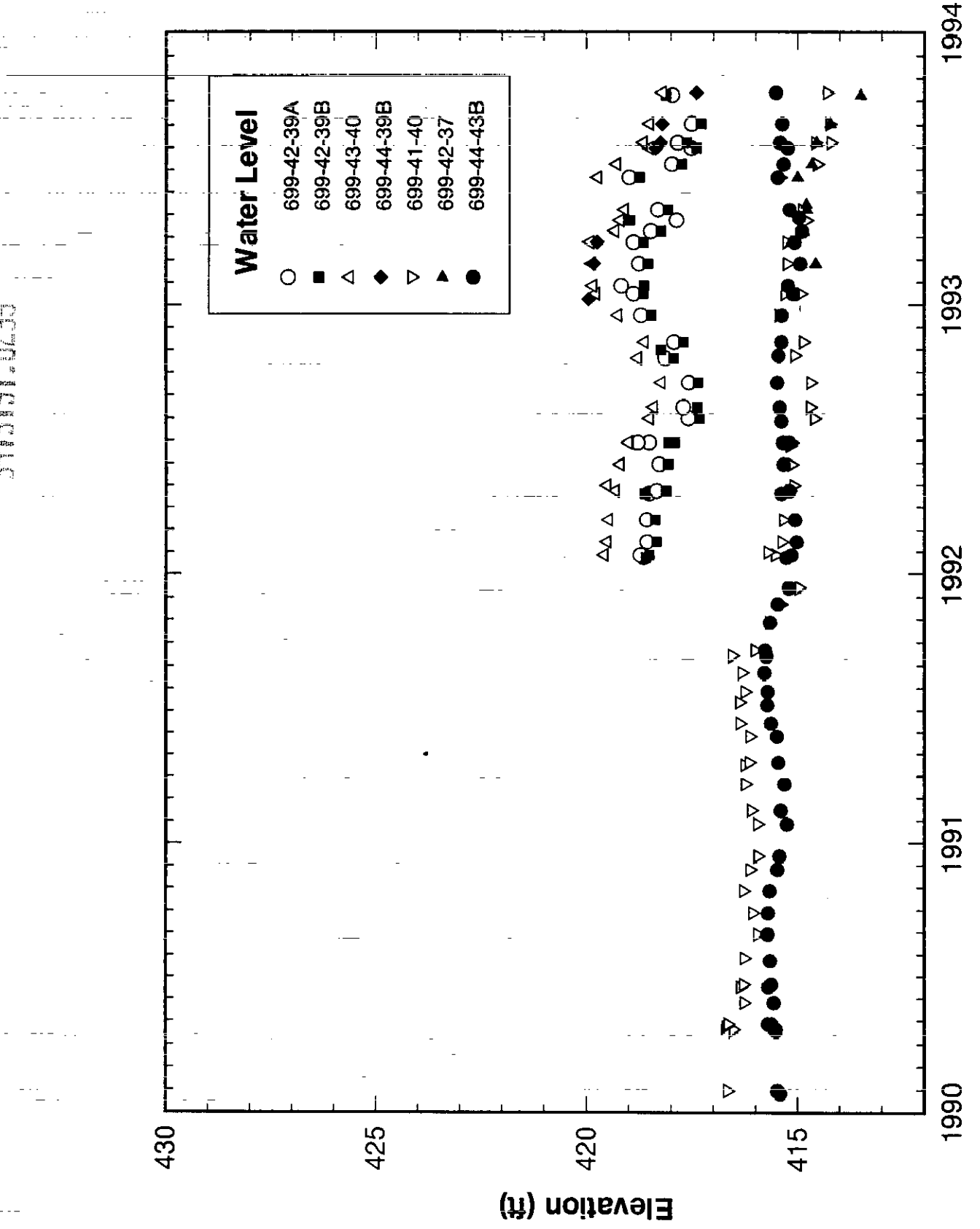
Estimates of flow velocity based on head gradients in May 1989, and aquifer properties (K and n), yielded velocities from 0.009 to 0.03 m/d (0.03 to 0.1 ft/d) for the Ringold Formation, and 15 to 46 m/d (50 to 150 ft/d) for the Hanford formation (WHC 1990). Performing this same calculation with head gradients observed for June 1993, flow velocities are estimated at 0.006 to 0.1 m/d (0.02 to 0.4 ft/d) for the Ringold Formation, and 2.0 to 51 m/d (7.0 to 168 ft/d) for the Hanford formation.

Flow velocity estimates at the W-049H TEDB site range from 0.002 to 0.2 m/d (0.005 to 0.08 ft/d) within the Ringold Formation unit A. Hydraulic conductivities used to calculate these estimates are derived from constant-discharge pumping tests conducted in early 1993. Effective porosities are laboratory estimates from borehole samples (Davis et al. 1993).

4.5.6.3 Evaluation of the Monitoring Well Network. Currently, the monitoring well network is adequate to detect contamination originating from the 216-B-3 Pond site. In early 1993, all wells in the network were evaluated for predicted longevity. Depth of water in the wells (from well bottom), amount of water above the pump intake, and the distance between intake and well bottom were tabulated. Some wells were found to have less than 0.6 m (2 ft) of water above the pump intake, with no room at the bottom of the well for lowering the pump. Fortunately, water levels in wells of this category appear to have stopped declining or have even slightly risen recently. Water levels in other wells are declining more quickly, but are at a sufficiently high level to allow a few to several years of monitoring at current rates of decline. Figure 4.5-5 is a composite hydrograph of wells at the B Pond system network showing typical patterns of water level decline. Water levels in wells at the distal edge of the groundwater mound, such as well 699-42-37, are declining as much as 0.3 m/yr (1 ft/yr). Water levels in others wells appear to be stable or declining very slowly (e.g., well 699-41-40). The water level in well 699-44-43B actually rose during 1993. This effect may be a partial result of the rerouting of discharges within the B Pond system during the last several years, thus affecting the location of the apex of the groundwater mound. Nevertheless, it is probable that some wells will eventually have to be replaced to maintain the effectiveness of the network.

Other investigations during 1993 indicated very low specific capacity in most wells in the network. Accordingly, it was tentatively recommended that the wells should be pumped at rates as low as 1.5 L/min (0.4 gal/min) to preserve well integrity and avoid excessive turbidity during sampling.

Figure 4.5-5. Composite Hydrograph for Representative Wells, 216-B-3 Pond.



4.5.7 References

40 CFR 264, "Standards for Owners and Operators of Permitted Hazardous Waste Facilities," *Code of Federal Regulations*, as amended.

40 CFR 265, "Interim Status Standards for Owners and Operators of Permitted Hazardous Waste Facilities," *Code of Federal Regulations*, as amended.

Comprehensive Environmental Response, Compensation, and Liability Act of 1980, 42 USC 9601 et seq.

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4.6 216-A-29 DITCH

G. L. Kasza
Westinghouse Hanford Company

4.6.1 Facility Overview

The 216-A-29 Ditch (A-29 Ditch) is a *Resource Conservation and Recovery Act of 1976* (RCRA) facility located east of the 200 East Area in the central portion of the U.S Department of Energy's (DOE) Hanford Site (Figure 1-1, Chapter 1.0). Put into service in 1955, the A-29 Ditch was an excavated unlined percolation trench, approximately 2 m (6 ft) wide and 2,000 m (3,600 ft) long, that received the effluent of the Plutonium-Uranium Extraction (PUREX) Plant chemical sewer line (CSL) and conducted it to the 216-B-3 Pond system (B Pond). Effluents disposed in the A-29 Ditch encountered from 83 m (272.5 ft) (at the head end of the ditch) to 61.5 m (202 ft) (at the discharge end) of unsaturated Hanford formation sediments above the water table. The water table beneath the A-29 Ditch occurs from slightly above to slightly below the hard-to-distinguish contact between the Hanford formation lower gravel sequence and the underlying Ringold gravel unit A. Ringold Formation sediments ranging in thickness from approximately 35 m (115 ft) at the south end to approximately 15 m (49 ft) comprise the saturated zone beneath the ditch (WHC 1992). The local geology and hydrogeologic setting for this part of the 200 East Area is introduced in Section 4.1.

During the early years of operation, the A-29 Ditch is known to have received almost daily sequential discharges of sodium hydroxide and sulfuric acid from the water treatment demineralizer during the early years of operation. The A-29 Ditch also received inadvertent spills of potentially hazardous chemicals. The A-29 Ditch is known to have received discharges of characteristically corrosive waste and waste containing the hazardous constituent hydrazine. In 1984, administrative and physical controls were implemented to avoid inadvertent discharges of hazardous chemicals.

In 1987, the DOE, Richland Operations Office (RL) proposed that the A-29 Ditch be closed under RCRA interim-status regulations (DOE 1987). A RCRA-compliant groundwater monitoring network was completed and the groundwater beneath the A-29 Ditch has been monitored since November 1988. In January 1990, statistical evaluation indicated that specific conductance in downgradient well 299-E25-35 had exceeded the critical mean. Immediate resampling of the well verified that the specific conductance in well 299-E25-35 was statistically greater than the critical mean. As required by the RCRA, a groundwater quality assessment plan was prepared and issued (Chou et al. 1990). As a result, monthly water level measurements and quarterly groundwater samples are collected from the assessment network as part of the assessment investigation. Groundwater sampling and analysis was not conducted between June 1990 and July 1991 because of the suspension of the groundwater analytical contract.

During 1991, a review of monthly measurements of the groundwater level in wells at the A-29 Ditch confirmed that the groundwater level beneath the A-29 Ditch continued to decline in a trend first recognized in late 1990

(DOE-RL 1991). Examination of project hydrographs indicated that the detection network was no longer in compliance with RCRA requirements because the well designated as the "upgradient well" (299-E25-32P) was no longer hydraulically upgradient of the facility. A new groundwater monitoring plan was prepared to bring the facility back into regulatory compliance by selecting adjacent monitoring wells to be used as the upgradient wells for the network (Kasza and Goodwin 1991). The groundwater monitoring plan also designated the locations of four additional monitoring wells. According to calculations using the MEMO model (Jackson et al. 1991), these wells increased the monitoring efficiency of the network to over 90% in the area downgradient of the A-29 Ditch (Kasza and Goodwin 1991). Three of the wells were sampled and the water levels in all four wells were measured initially during the fourth quarter of calendar year 1991. The remaining well was first sampled during the first quarter of 1992.

On July 15, 1991, effluent from the PUREX CSL was rerouted to the PUREX cooling water line and discharges to the A-29 Ditch were eliminated. The A-29 Ditch was backfilled and the location was graded and revegetated as an interim stabilization measure during autumn 1991 (Smith 1992). This activity marked the completion of *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) Milestone M-17-10 (Ecology et al. 1992).

The groundwater monitoring plan was revised again in 1992 to specify the locations of two additional groundwater monitoring wells (Kasza and Goodwin 1992). The locations of the new wells were selected to provide additional sampling locations near well 299-E25-35 to investigate the source and extent of the high specific conductance that forced the A-29 Ditch into assessment monitoring. The wells were completed and the first groundwater samples were collected during the fourth quarter of 1992. A record of the 1992 RCRA activities at the A-29 Ditch is contained in Kasza (1993a). The A-29 Ditch is located in the 200-PO-5 CERCLA operable unit. The RCRA closure plan is due to Ecology and EPA in March 1996.

4.6.2 Summary of 1993 Activities

During 1993, the monitoring activities required by the assessment plan and the groundwater monitoring plan were conducted. The depth to the water table was measured monthly in the wells that constitute the A-29 groundwater monitoring network, and quarterly in the wells used to gather supplementary data for the groundwater quality assessment program. Groundwater samples were collected for chemical analysis from the designated monitoring wells during each quarter. Site water levels and groundwater chemistry data were reported in the series of quarterly RCRA groundwater monitoring data reports (DOE-RL 1992, 1993a, 1993b, 1993c).

The Borehole Completion Data Package containing the drilling logs and construction records for the wells drilled in 1992 was issued during 1993 (Kasza 1993b).

A progress report on the A-29 groundwater quality assessment investigation was completed during 1993 but had not been released by the press time for this annual report.

4.6.3 Other Activities in 1993

Several wells in the A-29 monitoring network were sampled for sitewide operational monitoring purposes during 1993. There were no CERCLA program-sponsored activities in the 200-PO-5 operable unit, which encompasses the A-29 Ditch.

4.6.4 Sampling and Analysis Program

The A-29 groundwater monitoring network currently consists of 3 upgradient and 10 downgradient wells, all of which were constructed to RCRA standards. Thirteen additional wells are used to gather supplementary groundwater data for the groundwater quality assessment investigation. Details about the groundwater monitoring network and assessment wells are listed in Table 4.6-1. Figure 4.6-1 shows the locations of the wells. Several wells are co-sampled to satisfy the monitoring requirements of other RCRA facilities.

As part of the groundwater quality assessment investigation, the groundwater of the unconfined aquifer beneath the A-29 Ditch is sampled during each calendar quarter at the monitoring network wells and at selected assessment investigation wells (see Table 4.6-1 and Figure 4.6-1) (Chou et al. 1990). These groundwater samples are then analyzed for the constituents listed in Table 4.6-2. Analytical results are reported in the previously listed quarterly reports (see Section 4.6.1.2).

The groundwater quality assessment investigation is designed to determine whether the A-29 Ditch or one of the adjacent disposal sites is the actual source of the groundwater contamination. The determination of the groundwater flow direction and the analyses for the various chemical constituents listed in Table 4.6-2 are intended to identify both the contaminant(s) and the source of the contamination found at well 299-E25-35. As shown in Figure 4.6-1, there are several other disposal sites in the immediate vicinity that have the potential to affect the groundwater beneath the A-29 Ditch. Should the A-29 Ditch be confirmed as the source of the groundwater contamination, follow-on work will be planned to define the extent of the contamination and determine remedial strategies.

4.6.5 Groundwater Chemistry

4.6.5.1 Concentration Histories of Waste Indicators. As previously stated, the A-29 Ditch is the subject of a groundwater quality assessment investigation due to the elevated specific conductance of the groundwater samples collected from well 299-E25-35. As shown in Figure 4.6-2, the specific conductance values measured at this well during 1993 fell dramatically to approximately one-half of the historic range of values for this constituent. The specific conductance values measured at well 299-E25-35 during 1993 remain approximately 1.5 times higher than those of downgradient wells (299-E25-26 and 299-E25-28) and the upgradient well (699-43-43). The specific conductance measured for well 299-E25-35 during all 1993 sample collections was below the critical mean value (455.3 μmho/cm) established when the A-29 Ditch went into groundwater quality assessment monitoring in 1990.

Table 4.6-1. Monitoring Wells Used for the 216-A-29 Ditch.

Well	Aquifer	Sampling frequency	Water levels	Well standard	Other networks
299-E25-26[85]	Upper unconfined	Q	M	RCRA	Grout
299-E25-28[86]	Deep unconfined	Q	M	RCRA	Grout
299-E25-34[88]	Top of unconfined	Q	M	RCRA	--
299-E25-35[88]	Top of unconfined	Q	M	RCRA	--
299-E25-42[91]	Top of unconfined	Q	M	RCRA	--
299-E25-43[91]	Top of unconfined	Q	M	RCRA	--
299-E25-47[92]	Top of unconfined	Q	M	RCRA	--
299-E25-48[92]	Top of unconfined	Q	M	RCRA	--
299-E26-12[91]	Top of unconfined	Q	M	RCRA	--
299-E26-13[91]	Top of unconfined	Q	M	RCRA	--
299-E25-32P[88]	Top of unconfined	Q	M	RCRA	Grout
699-43-43[88]	Top of unconfined	Q	M	RCRA	B Pond
699-43-45[89]	Top of unconfined	Q	M	RCRA	B Pond
299-E17-15[88] A	Top of unconfined	Q	Q	RCRA	A-36B
299-E17-20[88] A	Top of unconfined	Q	Q	RCRA	A-10
299-E25-06[56] A	Top of unconfined	--	Q	PRE	--
299-E25-09[56] A	Top of unconfined	--	Q	PRE	--
299-E25-10[58] A	Deep unconfined	--	Q	PRE	--
299-E25-11[60] A	Deep unconfined	Q	Q	PRE	--
299-E25-18[76] A	Top of unconfined	Q	Q	PRE	--
299-E25-19[76] A	Top of unconfined	Q	Q	PRE	--
299-E25-20[76] A	Top of unconfined	Q	Q	PRE	--
299-E25-21[83] A	Top of Unconfined	Q	Q	PRE	--
299-E25-31[87] A	Top of unconfined	Q	Q	RCRA	Grout
299-E25-36[88] A	Top of unconfined	Q	Q	RCRA	A-10
299-E26-02[58] A	Top of unconfined	--	Q	PRE	--

Notes: Shading denotes upgradient wells. Superscript following well number denotes the year of installation.
A = assessment program well that is sampled for supplementary data.
M = frequency on a monthly basis.
PRE = well was constructed before RCRA-specified standards.
Q = frequency on a quarterly basis.
RCRA = well is constructed to RCRA-specified standards.

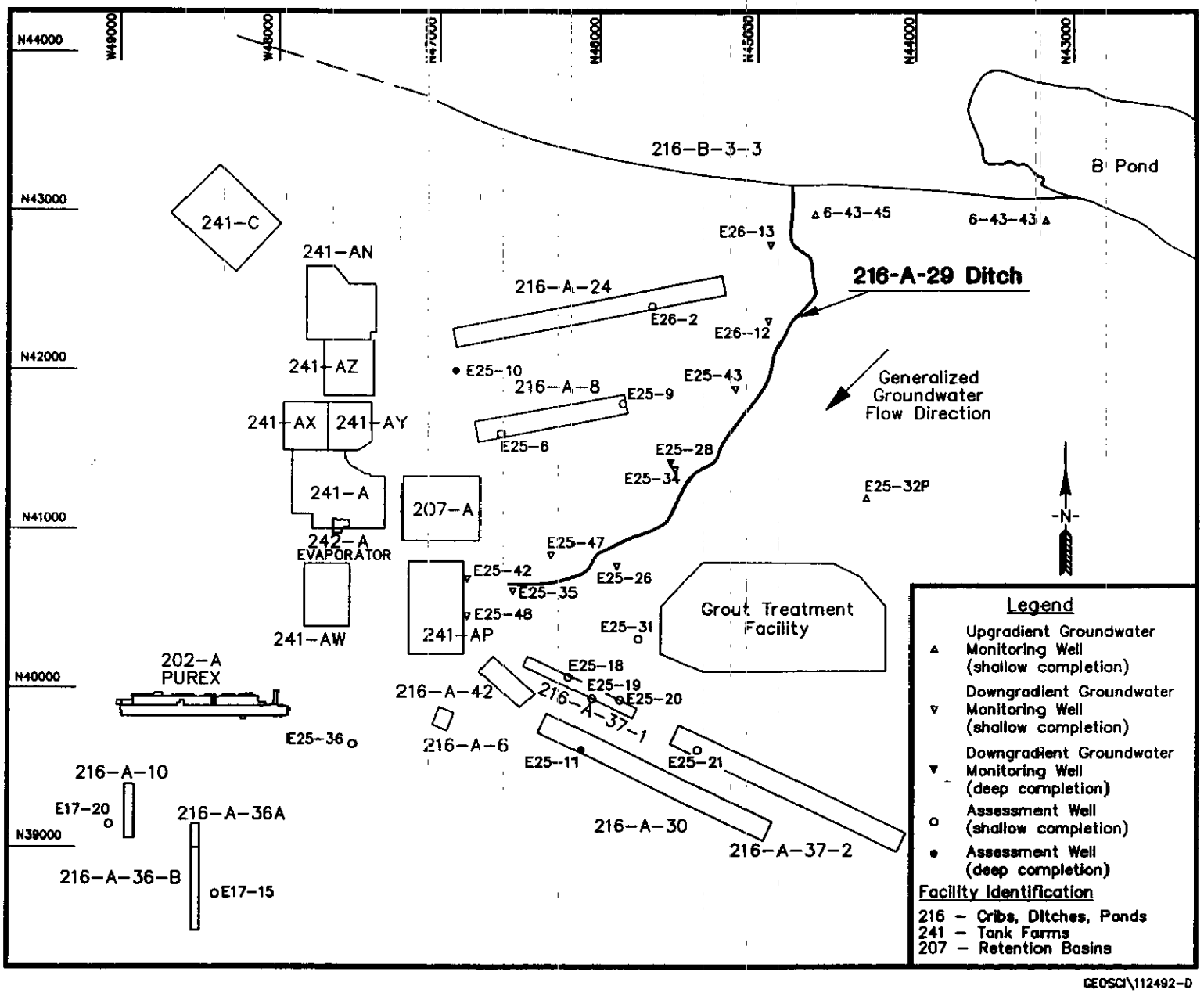


Figure 4.6-1. Monitoring Well Locations at the 216-A-29 Ditch.

Table 4.6-2. Constituents Analyzed in the Groundwater Beneath the 216-A-29 Ditch.

Contamination indicator parameters		
pH	Total organic carbon	
Specific conductance	Total organic halogen	
Groundwater quality parameters		
Chloride	Manganese	Sodium
Iron	Phenols	Sulfate
Drinking water parameters		
2,4-D	Endrin	Methoxychlor
2,4,5-TP Silvex	Fluoride	Nitrate
Arsenic	Gross alpha	Radium
Barium	Gross beta	Selenium
Cadmium	Lead	Silver
Chromium	Lindane	Toxaphene
Coliform bacteria	Mercury	Turbidity
Site-specific parameters for the 216-A-29 Ditch		
Ammonium	Hydrazine	Tritium
Assessment monitoring parameters for the 216-A-29 Ditch		
Anions	Pesticides	Semi-volatile organic compounds
Herbicides	Polychlorinated biphenyls	Volatile organic compounds
ICP metals		

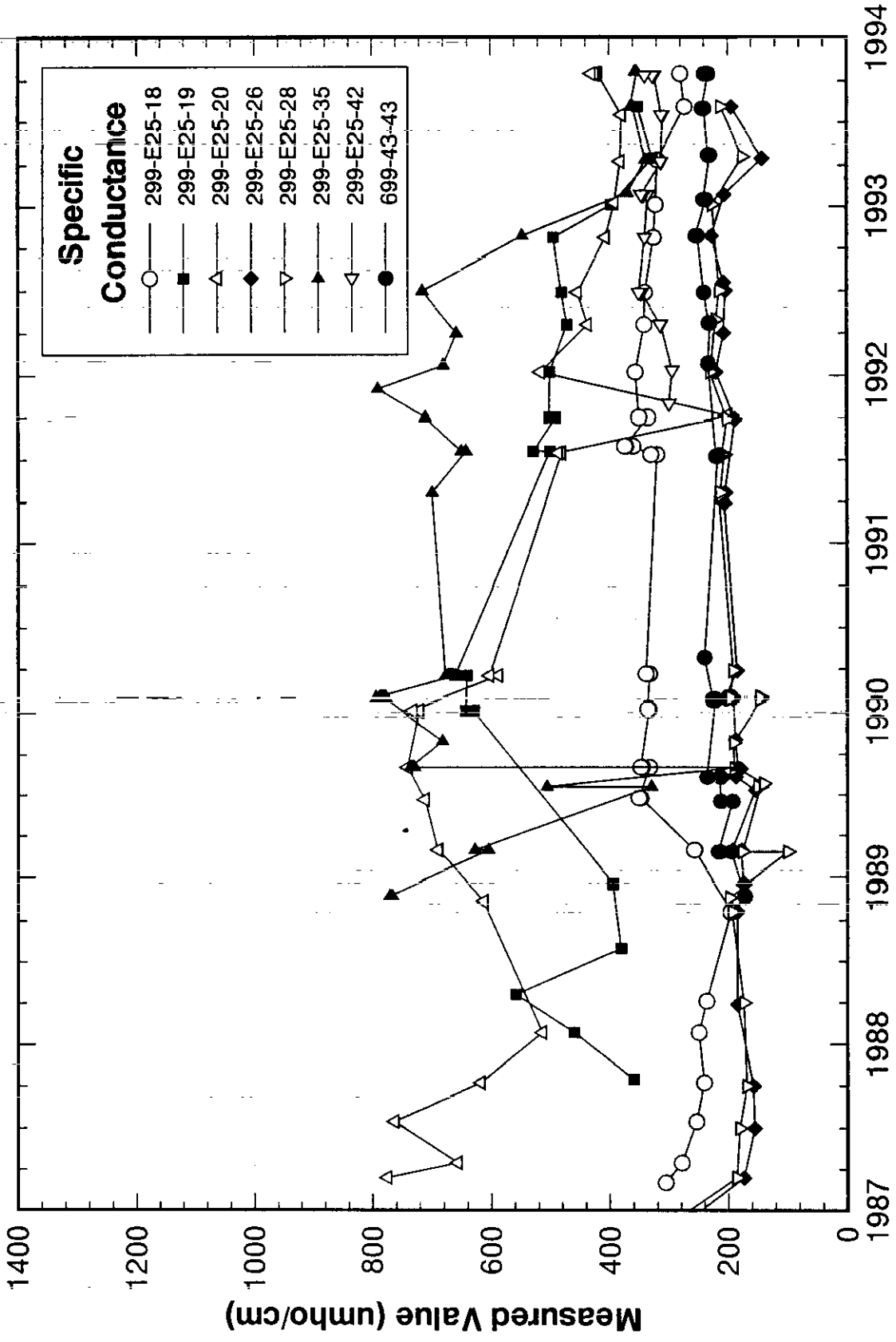
ICP = inductively coupled plasma, spectrogram method of analysis.

The site-specific hazardous constituent hydrazine (Table 4.6-2) was not found in concentrations above the detection limit during 1993.

Concentrations of unfiltered iron and chromium in several A-29 monitoring wells regularly exceeded the drinking water standards during 1993. A discussion of the occurrence of high concentrations of unfiltered iron and chromium is presented in Section 2.2.4.

Evaluation of the analytical chemistry data from all A-29 groundwater monitoring and assessment investigation wells indicates that there has been no degradation of groundwater quality beneath the A-29 Ditch during 1993. On the contrary, the reduction of specific conductance measured at well 299-E25-35 marks an improvement in groundwater quality.

Figure 4.6-2. Specific Conductance in the 216-A-29 Monitoring Network Wells.



4.6.5.2 Distribution of Waste Constituents. Analyses of the groundwater from nearby wells sampled for the groundwater quality assessment (Figure 4.6-1) indicate that there is no specific constituent responsible for the high specific conductance. Operational histories of the surrounding cribs suggest that the nearby 216-A-37-1 Crib may be the source of the high specific conductance detected at well 299-E25-35. Specific conductance at well 299-E25-42, the monitoring well closest to 299-E25-35, is higher than most other wells in the A-29 monitoring network, but is somewhat lower than the recently measured specific conductance values for 299-E25-35. The source of the elevated specific conductance values for wells 299-E25-18, 299-E25-19, and 299-E25-20 shown in Figure 4.6-2 may be the adjacent 216-A-37-1 Crib (see Figure 4.6-1). The possibility that the 216-A-37-1 Crib is the source of the elevated specific conductance values found in well 299-E25-35 continues to be investigated.

A report on the findings of the groundwater quality assessment investigation will be released in 1994. This document will contain a proposal to reduce the scope of the groundwater quality assessment investigation to concentrate sampling activity only in the area of elevated specific conductance.

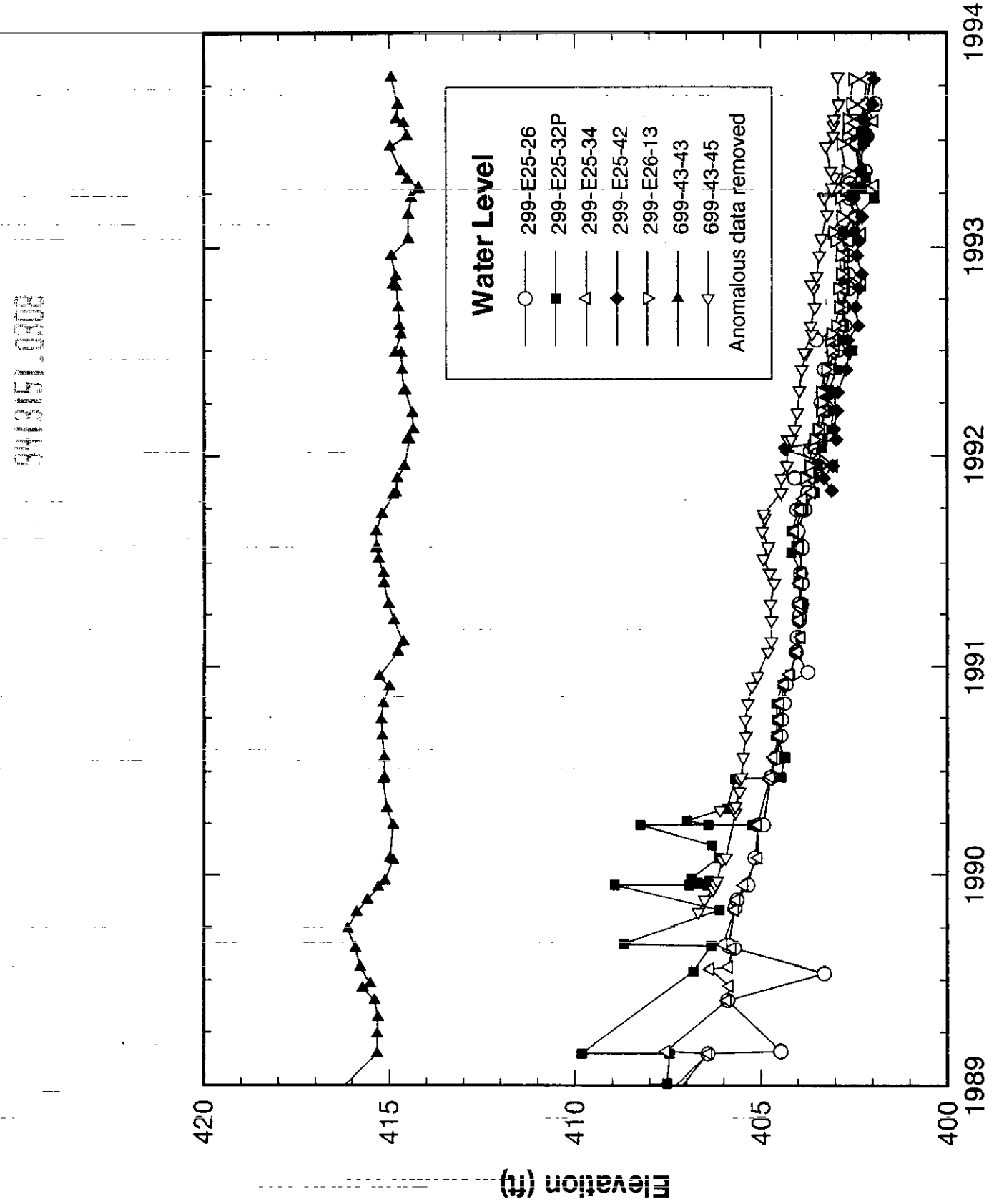
4.6.6 Groundwater Flow

4.6.6.1 Groundwater Flow Direction. The A-29 Ditch is located from 600 to 1,200 m (2,000 to 4,000 ft) west of the B Pond system. As indicated in Section 4.1, the regional groundwater flow pattern in the unconfined aquifer is radially away from the B Pond groundwater mound. Figure 4.6-4 presents June 1993 water level data from surrounding groundwater monitoring wells that more closely define the local water table and groundwater flow direction in the unconfined aquifer beneath the A-29 Ditch. As illustrated, the local groundwater flow direction near the A-29 Ditch ranges from a barely recognizable westward flow at the south end of the ditch to a west-southwestward flow at the north end of the ditch.

Hydrographs from local wells with nested piezometers (299-E25-29P and 299-E25-29Q, and 299-E25-32P and 299-E25-32Q) and a pair of adjacent A-29 network wells with shallow and deep completions (299-E25-34 and 299-E25-28) were examined for evidence of vertical gradients. Review of the data available indicates that any vertical head difference is so slight as to be indistinguishable from measurement errors.

Figure 4.6-3, the hydrograph of the A-29 Ditch groundwater monitoring network, depicts the change in the water table beneath the A-29 Ditch since the start of RCRA monitoring. The hydrograph shows that water levels across the network have gradually declined. The hydrograph and water table maps (see Figures 4.6-3 and 4.6-4) indicate that monitoring wells 699-43-43 and 699-43-45 continue to be upgradient of the facility and are appropriate upgradient monitoring wells for the ditch.

Figure 4.6-3. Hydrograph of the 216-A-29 Monitoring Network Wells.



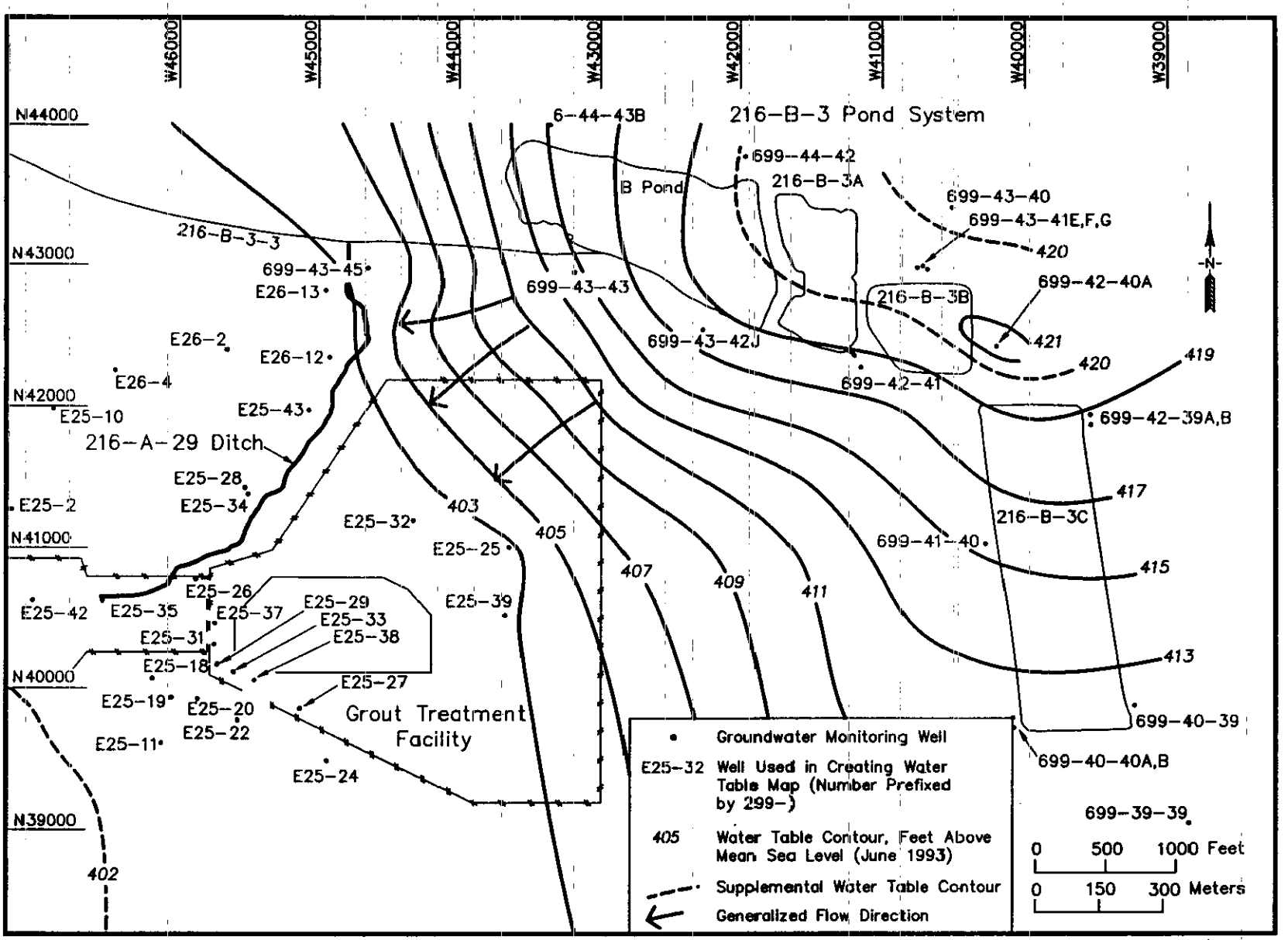


Figure 4.6-4. Water Table Contours in the 216-A-29 Area, June 1993.

Figure 4.6-1 shows the location of the A-29 Ditch in relation to other RCRA or operational facilities. In the past, the disposal of liquid effluent at some of these facilities may have produced local changes to the groundwater flow pattern and may have resulted in local contaminant flow counter to the regional flow direction. Considering the proximity of the 216-A-30 and 216-A-37-1 Cribs to well 299-E25-35 (see Figures 4.6-1 and 4.6-4) and the ongoing decrease in the regional water table, the potential for contaminant migration from any of these cribs toward well 299-E25-35 is possible. Water levels and groundwater movement in the area surrounding the A-29 Ditch are also discussed in Section 4.4, Grout Treatment Facility; Section 4.5, 216-B-3 Pond System; Section 4.7, 216-A-36B Crib; and Section 4.8, 216-A-10 Crib of this report.

4.6.6.2 Rate of Flow. As previously stated, groundwater movement beneath the A-29 Ditch is controlled by the water table mound beneath the B Pond. There is a 5.5- to 5.8-m (18- to 19-ft) difference in the potentiometric surface between the highest part of the B Pond mound and the monitoring wells immediately adjacent to the A-29 Ditch. The hydraulic gradient and groundwater flow velocity beneath different segments of the A-29 Ditch are dependent on the proximity of the segment to the B Pond mound. Using the June 1993 water table data, the hydraulic gradient at the northern end of the ditch (as measured between wells 299-E26-2 and 699-43-45) is approximately 0.002, while during the same time period, the hydraulic gradient beneath the southern portion of the ditch between wells 299-E25-32P and 299-E25-35 was 0.0003.

An estimate of the groundwater velocities in these two areas can be calculated from the measured gradients and aquifer test data from the A-29 monitoring network well 299-E25-42 using the Darcy's law equation:

$$V = \frac{Ki}{n} \qquad (1)$$

where:

V = Average linear velocity (m/d)
K = Hydraulic conductivity (m/d), 18.29 m/d (60 ft/d) (Kasza 1992)
i = Hydraulic gradient (m/m), 0.0003 to 0.002
n = Effective porosity, 0.25 (WHC 1990).

Groundwater flow velocities beneath the A-29 Ditch during June 1993 ranged from 0.02 m/d (0.07 ft/d) in the southern portion to 0.15 m/d (0.48 ft/d) in the northern portion.

4.6.6.3 Evaluation of Monitoring Well Network. Water levels in each well of the A-29 groundwater monitoring network were compared to the depth of the screen interval and the pump intake elevation to ensure that sufficient volumes of water exist for sampling purposes. There is no short-term need to replace any of the existing groundwater monitoring wells.

An evaluation of monitoring well locations confirmed that any effect the A-29 Ditch had on groundwater quality could be determined by the monitoring wells located upgradient and downgradient of the facility.

Groundwater quality beneath the A-29 Ditch will continue to be scrutinized in an effort to determine the source of the high specific conductance previously found at well 299-E25-35.

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4.7 216-A-36B CRIB

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4.7.1 Facility Overview

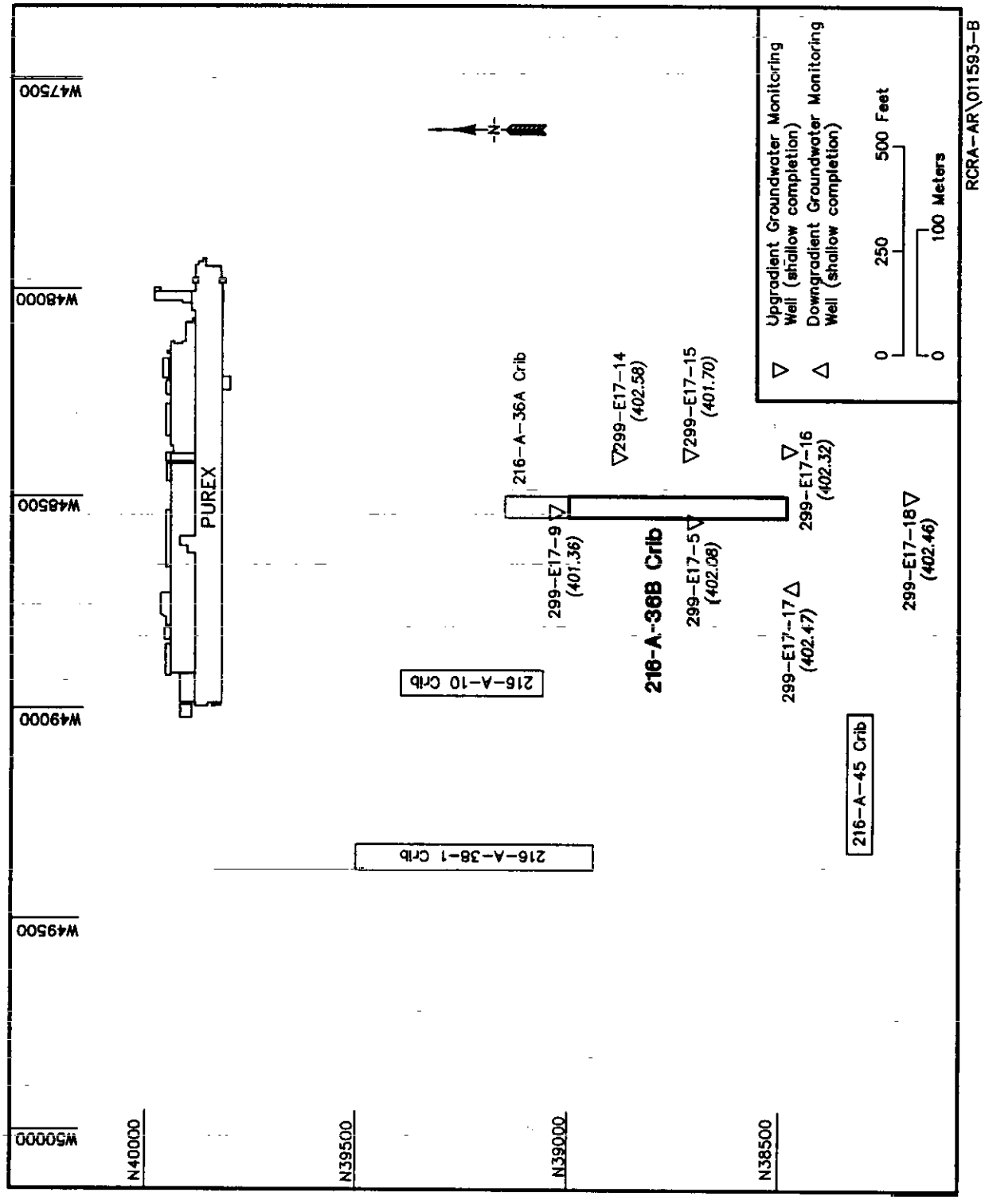
The 216-A-36B Crib, now retired from use, was a liquid waste disposal facility for the Plutonium-Uranium Extraction (PUREX) Plant. The 216-A-36B Crib is located in the 200 East Area approximately 360 m (1,200 ft) south of the PUREX Plant and is also approximately 110 m (360 ft) west of the nearby 216-A-10 Crib. The 216-A-36B Crib is the southernmost portion 150 m (500 ft) from the crib originally known as the 216-A-36 Crib (Figures 1-1 and 4.7-1). The original crib dimensions were 180 m (600 ft) long, 4 m (12 ft) wide, and 4 m (12 ft) deep. At the bottom of the crib, a 0.02-m-(0.5-ft-) diameter perforated distributor pipe was placed on a 0.3-m (1-ft) bed of gravel, covered with another 0.3 m (1 ft) of gravel, and backfilled to grade. Through the distribution pipe, ammonia scrubber distillate waste from the PUREX Plant was discharged to the crib and allowed to percolate through the soil column.

The original crib (216-A-36) received liquid effluent from September 1965 to March 1966. A substantial inventory of radionuclides was disposed and assumed to have infiltrated sediments near the inlet to the crib. To continue effluent discharge to the crib, the crib was divided into two sections: 216-A-36A and 216-A-36B. Grout was injected into the gravel layer to form a curtain separating the two sections. The liquid effluent discharge point was moved to the 216-A-36B Crib section and the 216-A-36A Crib section was no longer used. Discharge to the 216-A-36B Crib resumed in March 1966 and continued until 1972, when the crib was temporarily removed from service. The 216-A-36B Crib was placed back in service in November 1982 and operated until taken out of service again in October 1987.

Ammonia scrubber distillate disposed to the 216-A-36B Crib consisted of a condensate from nuclear fuel decladding operations in which zirconium cladding was removed from irradiated fuel by boiling in a solution of ammonium fluoride and ammonium nitrate. Other waste stream constituents included the radionuclides of tritium, ^{90}Sr, ^{137}Cs, ^{106}Ru, ^{60}Co, and uranium (Buelt et al. 1988).

Waste disposed in the 216-A-36B Crib encountered approximately 97 m (318 ft) of unsaturated Hanford formation sediments above the water table. The water table beneath the 216-A-36B Crib occurs very near the hard-to-distinguish contact between the unsaturated Hanford formation upper gravel and sandy sequences and the underlying Ringold gravel unit E. Approximately 40 m (130 ft) of Ringold Formation sediments comprise the saturated zone beneath the 216-A-36B Crib (WHC 1992). Section 4.1 provides additional information on the hydrogeologic setting for the 216-A-36B Crib.

Figure 4.7-1. Monitoring Well Locations for the 216-A-36B Crib.



An interim-status *Resource Conservation and Recovery Act of 1976* (RCRA) groundwater monitoring program has been in operation at the 216-A-36B Crib since May 1988. The groundwater monitoring program at the 216-A-36B Crib is currently in indicator parameter evaluation status. The RCRA closure/post-closure plan for the 216-A-36B Crib is scheduled to be submitted to the Washington State Department of Ecology (Ecology) and the U.S. Environmental Protection Agency (EPA) in March 1996. This action will satisfy the *Hanford Federal Facility Agreement and Consent Order* Milestone M-20-34 (Ecology et al. 1992).

4.7.2 Summary of 1993 RCRA Activities

Groundwater samples were collected and analyzed for the indicator parameter constituents during 1993 for the wells in the 216-A-36B groundwater monitoring network. The groundwater samples were collected during December 1992 and June 1993. The depth to the groundwater beneath the 216-A-36B Crib was measured in the monitoring network wells during each quarter of the report period. The groundwater chemistry data and water level measurements for the period covered by this report were reported in Barnett (1992, 1993) and Kasza (1993a, 1993b).

During 1993, in response to the declining water table beneath the 216-A-36B Crib, water levels in the monitoring wells were compared to the sample pump intake elevations and to the depth of the well bottoms. There is no near-term need to replace any of the existing monitoring well network with deeper wells as all wells have an adequate depth of water in the well to cover the anticipated water level decline for the next several years. Several sampling pumps were lowered to ensure adequate sample quality.

4.7.3 Other Activities in 1993

There were no changes in the PUREX Plant operational status that affected the 216-A-36B Crib during 1993. In addition, there were no *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) program-sponsored activities in the 200-PO-2 operational unit, which encompasses the 216-A-36B Crib.

4.7.4 Sampling and Analysis Program

The 216-A-36B Crib groundwater monitoring well network is illustrated in Figure 4.7-1. The monitoring network consists of one well located upgradient of the facility and six wells located downgradient. Monitoring well information is presented in Table 4.7-1. All wells in the network meet RCRA construction standards except wells 299-E17-5 and 299-E17-9. These two wells are older remediated wells with perforated carbon steel casing and they may be improperly sealed. These wells are not used in statistical evaluation of the groundwater monitoring network.

Table 4.7-1. Monitoring Wells in the 216-A-36B Crib Network.

Well	Aquifer	Sampling frequency	Water levels	Well standard	Other networks
299-E17-16[88]	Top of unconfined	S	Q	RCRA	--
299-E17-17[88]	Top of unconfined	S	Q	RCRA	--
299-E17-18[88]	Top of unconfined	S	Q	RCRA	--
299-E-17-15[88]	Top of unconfined	Q	Q	RCRA	216-A-29
299-E17-14[88]	Top of unconfined	S	Q	RCRA	--
299-E17-9[68]	Top of unconfined	S	Q	PRE	--
299-E17-5[65]	Top of unconfined	S	Q	PRE	--

Notes: Shading denotes upgradient wells. Superscript following well number denotes the year of installation.
PRE = well was constructed before RCRA-specified standards.
Q = frequency on a quarterly basis.
RCRA = well is constructed to RCRA-specified standards.
S = frequency on a semiannual basis.

Groundwater samples from the 216-A-36B network wells are collected and analyzed semiannually for contamination indicator parameters, groundwater quality parameters, drinking water parameters (DWS) (40 *Code of Federal Regulations* [CFR] 264), and constituents of site-specific concern (Table 4.7-2).

Well 299-E17-15 is shared with the groundwater monitoring network for the 216-A-29 Ditch. This well is sampled on a quarterly basis to provide supplementary local groundwater quality data for the 216-A-29 Facility groundwater quality assessment program.

4.7.5 Groundwater Chemistry

The 216-A-36B Crib is located directly over several plumes that define areas where specific constituents exceed the DWSs (Section 4.1). While the nitrate and gross beta plumes are localized beneath the 216-A-36B Crib, the tritium and ^{129}I plumes are more extensive and underlie other cribs. It is difficult to determine if the 216-A-36B Crib is affecting the groundwater quality in the area because of the similarities in effluent constituents disposed at other cribs, the proximity of these liquid effluent disposal sites to the 216-A-36B Crib, and also because of the rapid rate of groundwater movement through the area.

4.7.5.1 Elevated Constituents. None of the four critical means for the contamination indicator parameters were exceeded in the 216-A-36B Crib monitoring wells during 1993. Constituents that exceeded DWSs in the

Table 4.7-2. Constituents Analyzed in the 216-A-36B Crib.

Contamination indicator parameters		
pH	Total organic carbon	
Specific conductance	Total organic halogen	
Groundwater quality parameters		
Chloride	Manganese	Sodium
Iron	Phenols	Sulfate
Drinking water parameters		
2,4-D	Endrin	Methoxychlor
2,4,5-TP Silvex	Fluoride	Nitrate
Arsenic	Gross alpha	Radium
Barium	Gross beta	Selenium
Cadmium	Lead	Silver
Chromium	Lindane	Toxaphene
Coliform bacteria	Mercury	Turbidity
Site-specific parameters		
Ammonium ion	Gamma scan	Zinc
Benzyl alcohol	Tritium	

216-A-36B network during 1993 are: gross beta, nitrate, tritium, unfiltered iron, unfiltered chromium, and ^{90}Sr (Barnett 1992, 1993; Kasza 1993a, 1993b). Requests for Analytical Data Evaluations were submitted for all unusual occurrences of constituents.

The DWS for gross beta (DWS = 50 pCi/L) was exceeded at least once during 1993 in wells 299-E17-14, 299-E17-15, and 299-E17-16. The highest value was found in well 299-E17-15 (115 pCi/L on 12/15/92). Decay of some of the radionuclides in the 216-A-36B waste stream or the movement of groundwater may account for the reduced observed gross beta values.

Nitrate concentrations (Figure 4.7-2) remained above the DWS (45,000 ppb) in all wells during 1993 except wells 299-E17-5, 299-E17-17, and 299-E17-18. Since the resumption of sample collection after the 1990-1991 hiatus, the general trend for nitrate in the network is downward in all wells except 299-E17-16 and 299-E17-18.

The tritium DWS (20,000 pCi/L) was exceeded in all wells in the 216-A-36B groundwater monitoring network during both of the 1993 sampling events (Figure 4.7-3). The measured concentrations of tritium are unchanged to slightly lower than last year's results.

Figure 4.7-2. Nitrate Concentrations in the 216-A-36B Network Wells.

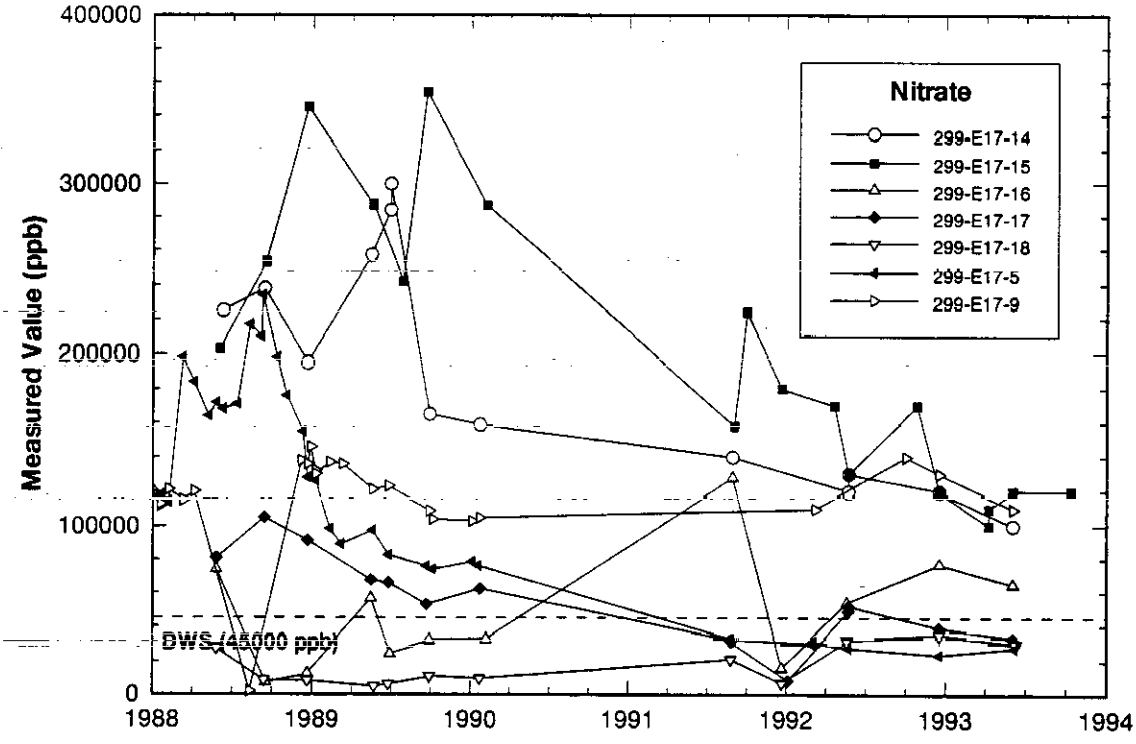
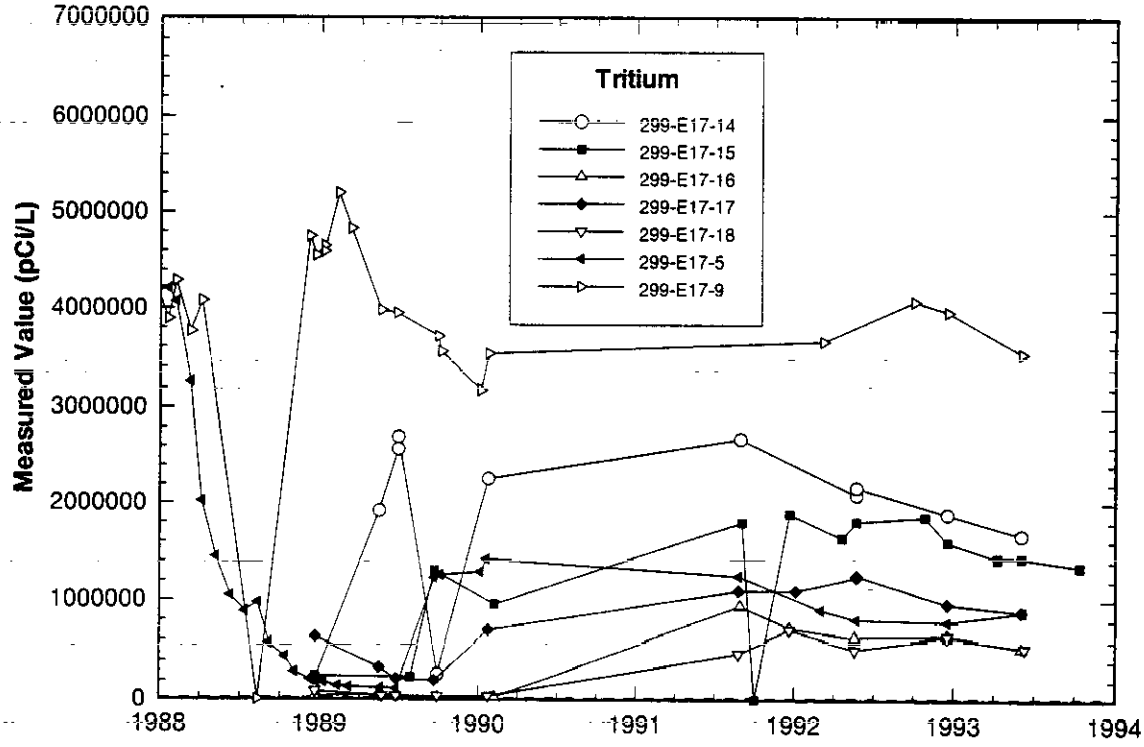


Figure 4.7-3. Tritium Concentrations in the 216-A-36B Network Wells.



During 1993, the chromium DWS (100 ppb) was exceeded in unfiltered samples from wells 299-E17-15, 299-E17-16, and 299-E17-18. Unfiltered analytes exceeding the DWSs are the subject of a discussion in Section 2.2.4.

Iron in unfiltered samples also exceeded the DWS (300 ppb) in 1993 for wells 299-E17-9, 299-E17-15, 299-E17-16, and 299-E17-18. The discussion in Section 2.2.4 also pertains to this analyte.

4.7.5.2 Statistical Evaluation. During 1993, groundwater quality beneath the 216-A-36B Crib was subject to the RCRA-required continuing evaluation for sites under indicator parameter evaluation status. Appendix C presents an explanation of the statistical evaluation method performed on the groundwater analytical results. The statistical evaluations of the water quality data for the past year consisted of comparisons between upgradient and downgradient wells for any indication of contamination in the groundwater underlying the facility. Statistical analyses required by 40 CFR 264, 40 CFR 265.93(b), and *Washington Administrative Code* (WAC) 173-303-400 were performed on the samples collected from September 1988 to June 1989 for upgradient well 299-E17-17 (DOE-RL 1991). Results are presented in Table 4.7-3. This table lists the background average, background standard deviation, and critical mean (or critical range, in the case of pH) and upgradient/downgradient comparison values for the four contamination indicator parameters. The critical mean (or critical range) is the value to which current and future averages of quadruplicate measurements are compared. For the 216-A-36B Crib site, the calculated critical range for pH was too large to be meaningful. An alternate range for upgradient/downgradient comparisons was calculated by using upgradient data collected from September 1988 to June 1993 (see Appendix C). Downgradient wells did not exceed the contamination indicator parameter critical means during 1993.

The data from the upgradient well that were used to compute critical means came from a different laboratory than recent data. The comparability of recent indicator parameter data with historical data was evaluated to assess impacts of the change of analytical laboratory and the time gap observed between sampling events (DOE-RL 1992). Recent values of pH, specific conductance, and total organic carbon are all comparable to historical data. The critical mean for total organic halogen is presented here for the purpose of completeness only. It will not be used for this year's comparisons because of unsatisfactory laboratory audit findings (see Appendix A).

4.7.6 Groundwater Flow

4.7.6.1 Groundwater Flow Direction. Water levels in the 216-A-36B network were measured quarterly and during semiannual sampling events in 1993 (Barnett 1992, 1993; Kasza 1993a, 1993b). Water level data, through September 1993, for all wells in the 216-A-36B network are presented in Figure 4.7-4. The average water level decline in these wells was approximately 0.15 m (0.5 ft) between June 1992 and June 1993. This trend is a continuation of the long-term decline in water levels that began during 1988 after the shutdown of PUREX Plant operations and cessation of discharges to the 216-A-36B Crib and other nearby liquid effluent disposal facilities.

Table 4.7-3. Critical Means Table for 20 Comparisons--Background Contamination Indicator Parameter Data for the 216-A-36B Crib.[a,b]

Constituent (unit)	n	df	t_c	Average background	Standard deviation	Critical mean	Upgradient/ downgradient comparison value
Specific conductance (μmho/cm)	4	3	12.924	298.31	51.291	1,039.4	1,039.4
Field pH	4	3	16.326	7.811	0.175	[4.62, 11.00]	[6.29, 9.27][f]
Total organic carbon[c] (ppb)	4	3	12.924	558.63	149.13	2,713.5	2,713.5
Total organic halogen[d] (ppb)	4	3	12.924	3.29	3.25	50.3	NC[e]

[a]Data collected from September 1988 to June 1989 for upgradient well 2-E17-17. Values calculated based on 20 comparisons.

[b]The following notations are used in this table:

df = degrees of freedom (n-1)

n = number of background replicate averages

t_c = Bonferroni critical t-value for appropriate df and 20 comparisons.

[c]Critical mean were calculated from values reported below the contractually required quantitation limits (DOE-RL 1991).

[d]Critical mean were calculated using data analyzed by U.S. Testing, Inc., Richland, Washington.

[e]Upgradient/downgradient comparison value for total organic halogen cannot be established because problems associated with data quality preclude the determination of total organic halogen limit of quantitation.

[f]Upgradient/downgradient comparison values for pH were calculated using data collected from September 1988 to June 1993 (well 2-E17-17) because the critical range calculated using four quarters of data is too large to be meaningful.

NC = not calculated.

Groundwater flow directions in the vicinity of the 216-A-36B Crib are poorly defined because the local hydraulic gradient is extremely low (Figures 4.7-1 and 4.7-5). Based on the regional water table maps (see Figures 2-4 and 4.1-13), groundwater flow is toward the south to southeast.

4.7.6.2 Rate of Flow. Water table head gradient is estimated to be in the range of 0.0001 to 0.0002 (WHC 1992). Based on these gradient estimates and estimates of hydraulic conductivity (150 to 300 m/day [500 to 1,000 ft/day])

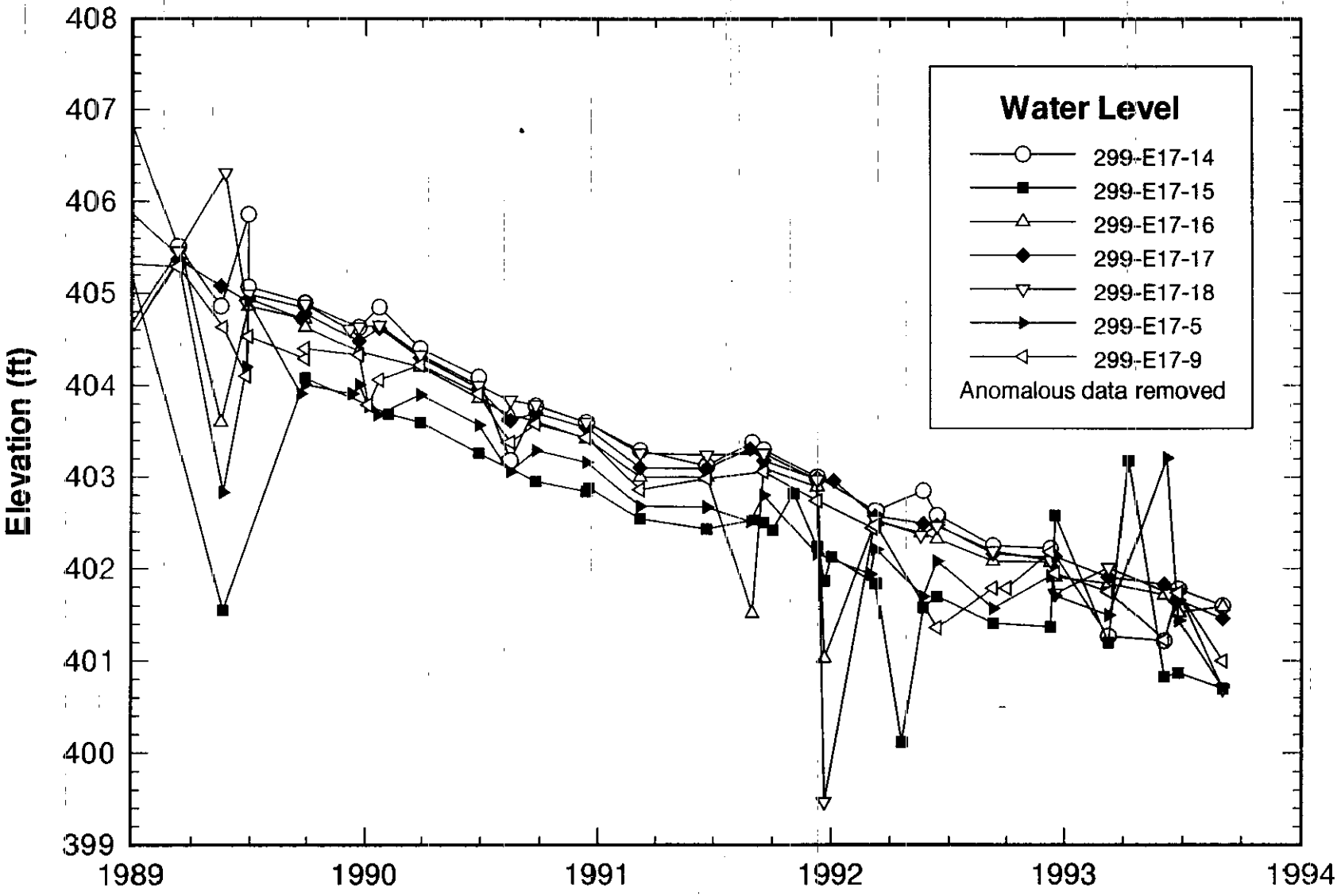
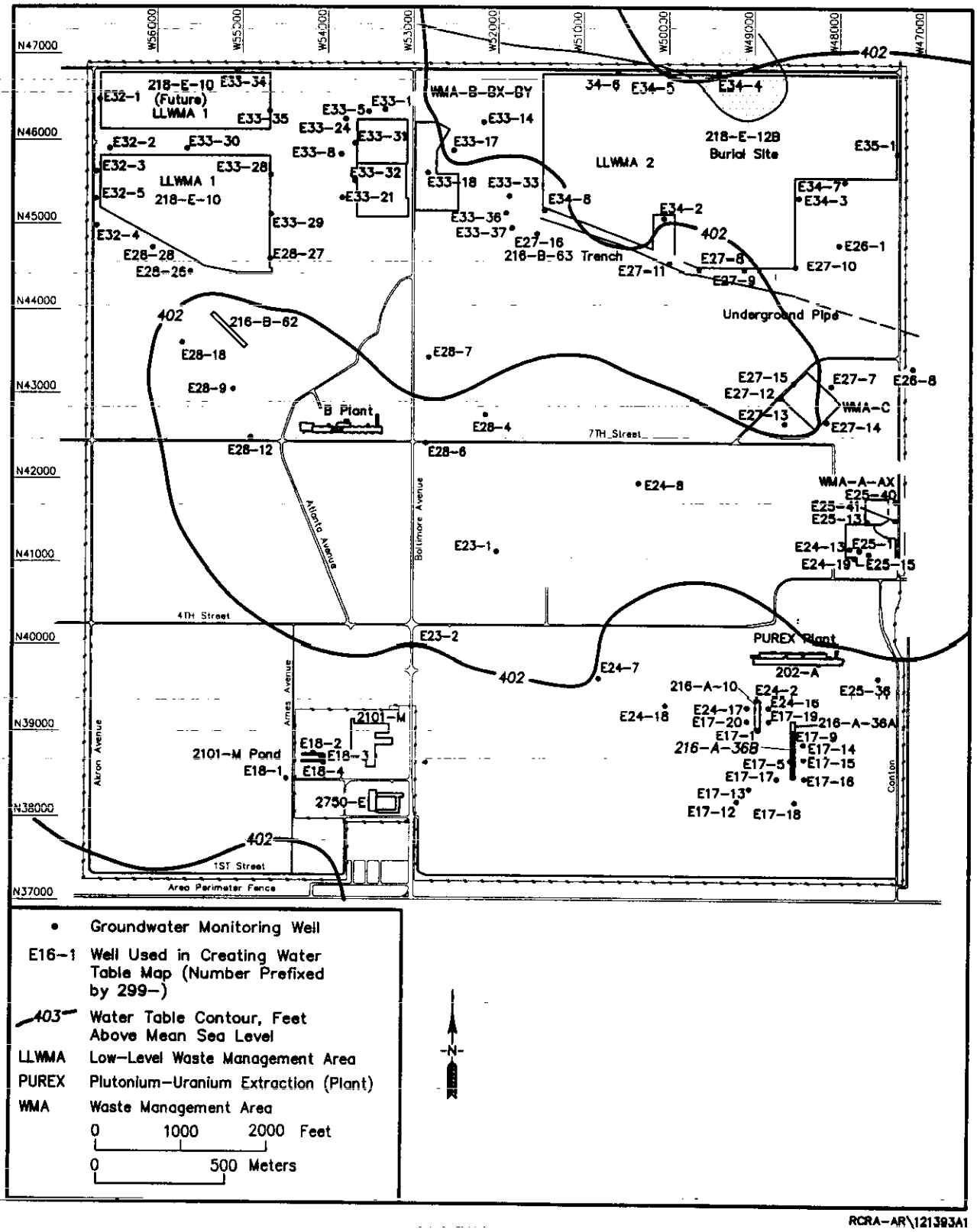


Figure 4-7-4. Composite Hydrograph for the 216-A-36B Network Wells.

Figure 4.7-5. 200 East Area and 216-A-36B Crib Vicinity Water Table Map, June 1993.



and porosity (0.25) for the unconfined aquifer near the 216-A-36B Crib (WHC 1992), groundwater flow velocities may range from 0.06 to 0.2 m/day (0.2 to 0.8 ft/day). Regional-scale, water table elevation changes indicate that local groundwater flow is toward the south or southeast. The tritium plume maps also indicate that groundwater flow is directed to the southeast (see Figure 4.1-22, Section 4.1).

It is not possible to determine the vertical groundwater gradient due to the lack of paired well completions in the surrounding area.

4.7.6.3 Evaluation of Monitoring Well Network. Water levels are measured regularly and the adequacy of the existing monitoring network is evaluated accordingly. Because of the steadily decreasing water levels since the newest wells in the network were drilled in 1988, the water level in each well was compared to the depth of the screened interval and pump intake elevation to ensure that sufficient volumes of water exist for sampling purposes. As stated in Section 4.7.2, there is no near-term need to replace any of the existing groundwater monitoring wells. Because the 216-A-36B Crib is surrounded on all sides by seven groundwater monitoring wells, the downgradient monitoring well network is currently adequate to monitor the quality of the groundwater beneath the 216-A-36B Crib.

Because of the low local hydraulic gradient and the continuing decline of the regional water table, the evaluation of the upgradient well is difficult. Very small relative changes in water levels between wells may constitute a reversal in gradient. In addition, measurement errors, undetected surveying errors, and daily water level fluctuations may affect the accuracy of reported water levels and the estimates of flow direction and head. Figure 4.7-4 shows that although well 299-E17-17 was selected as an upgradient monitoring point for the 216-A-36B Crib, two other wells in the network have had water levels as high or higher in elevation during certain periods. On several occasions during the current report period, downgradient wells 299-E17-14 and 299-E17-18 have had higher water levels than upgradient well 299-E17-17. The use of well 299-E17-7 as the upgradient groundwater monitoring well may not be appropriate in view of the current water table configuration. This problem will be evaluated further and the network will be changed if needed.

4.7.7 References

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4.8 216-A-10 CRIB

G.L. Kasza
Westinghouse Hanford Company

4.8.1 Facility Overview

The 216-A-10 Crib, now retired from use, was a liquid waste disposal facility for the Plutonium-Uranium Extraction (PUREX) Plant. The 216-A-10 Crib is located in the 200 East Area approximately 122 m (400 ft) south of the PUREX Plant. It is also located approximately 110 m (360 ft) east of the nearby 216-A-36B Crib (Figures 1-1 and 4.8-1).

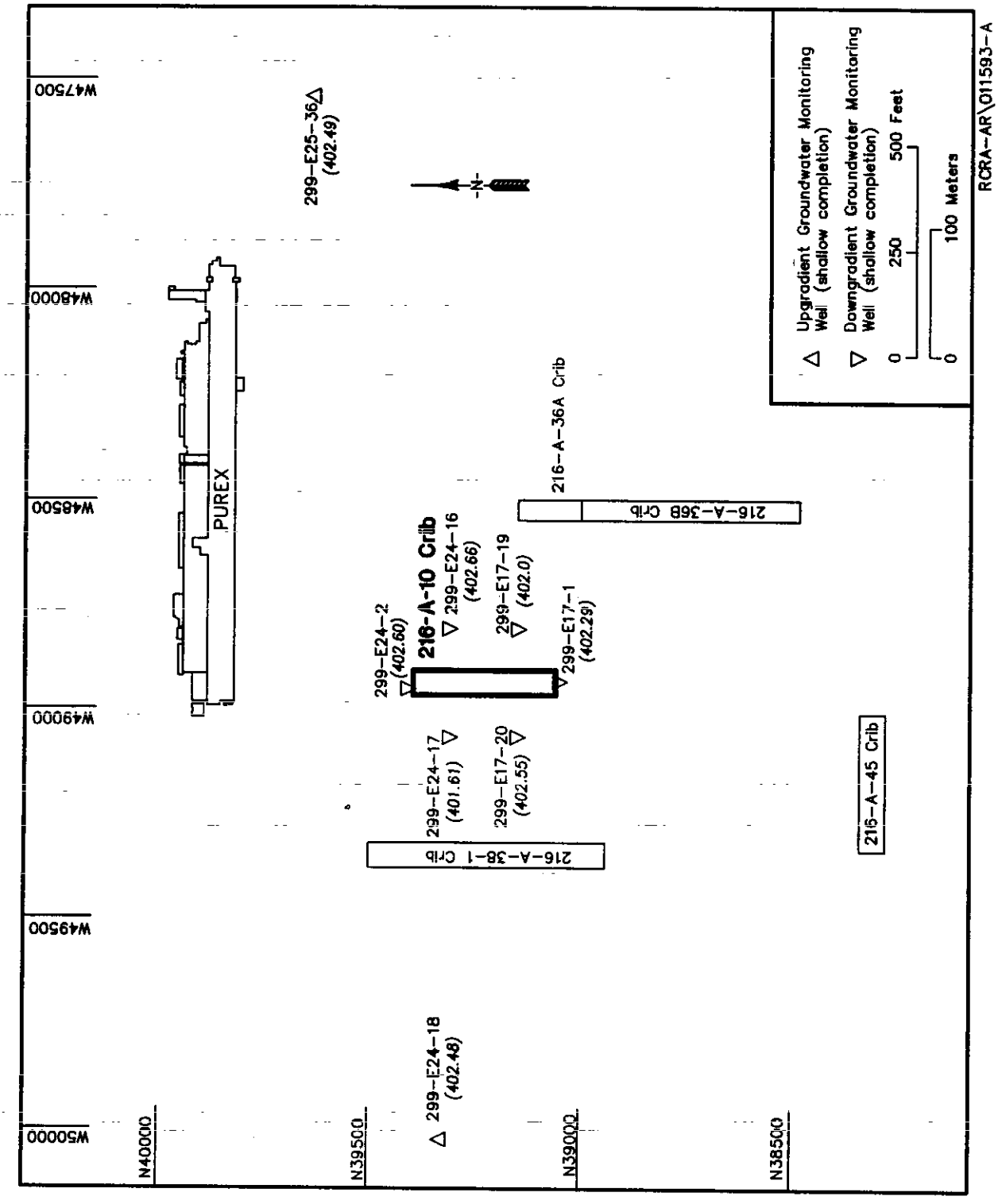
The 216-A-10 Crib is 84 m (275 ft) long, has a V-shaped cross section, and is 14 m (45 ft) deep. Several waste streams, collectively described as the process distillate discharge, were disposed to the 216-A-10 Crib and were allowed to percolate through the soil column. The 216-A-10 Crib first received liquid wastes over a 4-month period during the PUREX startup in 1956. In 1961, the 216-A-10 Crib replaced the 216-A-5 Crib and received PUREX effluent continuously until 1973. Periodic discharges were received in 1977, 1978, and 1981. From 1982 to 1987, effluent discharges resumed on a continuous basis. Discharge between 1981 to 1986 averaged 1 x 10^8 L (2.6 x 10^7 gal) per year. In 1987, the 216-A-10 Crib was taken out of service and replaced by the 216-A-45 Crib.

The process distillate discharge waste stream to the 216-A-10 Crib was characteristically acidic and contained concentrated salts. Other waste stream constituents included (1) aliphatic hydrocarbon compounds; (2) organic complexants; and (3) the radionuclides: plutonium, uranium, ^{90}Sr, ^{60}Co, ^{134}Cs, ^{137}Cs, ^{103}Ru, ^{106}Ru, and tritium (Aldrich 1987).

Waste disposed in the 216-A-10 Crib encountered approximately 97 m (318 ft) of unsaturated Hanford formation sediments above the water table. The water table beneath the 216-A-10 Crib occurs very near the hard-to-distinguish contact between the unsaturated Hanford formation upper gravel and sandy sequences and the underlying Ringold gravel unit E. Approximately 40 m (130 ft) of Ringold Formation sediments comprise the saturated zone beneath the 216-A-10 Crib (WHC 1992). Section 4.1 provides additional information on the hydrogeologic setting for the 216-A-10 Crib.

An interim-status *Resource Conservation and Recovery Act of 1976* (RCRA) groundwater monitoring network has been active at the 216-A-10 Crib since November 1988. The groundwater monitoring program is currently in indicator parameter evaluation status. The RCRA closure/post-closure plan for the 216-A-10 Crib is scheduled to be submitted to the Washington State Department of Ecology (Ecology) and the U.S. Environmental Protection Agency (EPA) in March 1996. This document will satisfy the *Hanford Federal Facility Agreement and Consent Order*, Milestone M-20-33 (Ecology et al. 1992).

Figure 4.8-1. Monitoring Well Locations for the 216-A-10 Crib.



4.8.2 Summary of 1993 RCRA Activities

Groundwater samples were collected and analyzed for the indicator parameter constituents during 1993 for the wells in the 216-A-10 Crib groundwater monitoring network. These samples were collected during December 1992 and June 1993. The depth to the groundwater beneath the 216-A-10 Crib was measured in the monitoring network wells during sample collection and for each quarterly report period. The groundwater chemistry data and water level measurements for the period covered by this report were reported quarterly in Barnett (1992, 1993) and Kasza (1993a, 1993b).

During 1993, in response to the declining water table beneath the 216-A-10 Crib, water levels in the monitoring wells were compared to the sample pump intake elevations and to the depth of the well bottoms. It was determined that there is no near-term need to replace any of the existing monitoring well network with deeper wells as all wells have adequate depths for sampling over the next several years. However, sampling pumps need to be lowered in several wells to ensure adequate sample availability and quality.

4.8.3 Other Activities in 1993

There were no changes in the PUREX Plant operational status that affected the 216-A-10 Crib during 1993. In addition, there were no *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) program-sponsored activities in the 200-PO-2 operational unit, which encompasses the 216-A-10 Crib.

4.8.4 Sampling and Analysis Program

The 216-A-10 Crib monitoring network (Figure 4.8-1 and Table 4.8-1) includes two upgradient wells and six downgradient wells. All RCRA monitoring network wells meet RCRA construction standards except wells 299-E17-1 and 299-E24-2. These two wells are older, remediated wells with perforated carbon steel casing, and they may be improperly sealed. These wells are not used in statistical evaluation of the groundwater monitoring network.

Groundwater samples from the 216-A-10 monitoring network are collected and analyzed semiannually to detect and quantify any groundwater contamination originating from the facility. Groundwater samples are analyzed for a series of constituents which include: (1) interim primary drinking water parameters (40 *Code of Federal Regulations* [CFR] 265), (2) groundwater quality parameters, (3) groundwater contamination indicator parameters, and (4) site-specific constituents. The site-specific constituents were selected on knowledge of the waste streams formerly discharged to the 216-A-10 Crib. Table 4.8-2 lists these constituents. This sample and analysis program exceeds RCRA minimum requirements (40 CFR 264 and 40 CFR 265).

Wells 299-E17-20 and 299-E25-36 are also used for the 216-A-29 groundwater monitoring network. These wells are sampled on a quarterly basis to satisfy the groundwater quality assessment monitoring requirements for the 216-A-29 Facility.

Table 4.8-1. Monitoring Wells in the 216-A-10 Crib Network.

Well	Aquifer	Sampling frequency	Water levels	Well standards	Other networks
299-E24-18[88]	Top of unconfined	S	Q	RCRA	--
299-E25-36[88]	Top of unconfined	Q	Q	RCRA	216-A-29
299-E17-19[88]	Top of unconfined	S	Q	RCRA	--
299-E17-20[88]	Top of unconfined	Q	Q	RCRA	216-A-29
299-E24-16[88]	Top of unconfined	S	Q	RCRA	--
299-E24-17[88]	Top of unconfined	S	Q	RCRA	--
299-E17-1[55]	Top of unconfined	S	Q	PRE	--
299-E24-2[56]	Top of unconfined	S	Q	PRE	--

Notes: Shading denotes upgradient wells. Superscript following well number denotes the year of installation.
PRE = well was constructed before RCRA-specified standards.
Q = frequency on a quarterly basis.
RCRA = well is constructed to RCRA-specified standards.
S = frequency on a semiannual basis.

4.8.5 Groundwater Chemistry

The 216-A-10 Crib is located in a region where several groundwater contaminant plumes define areas where specific constituents exceed the drinking water standards (DWS) (Section 4.1). While nitrate and tritium concentrations exceed the DWSs beneath the 216-A-10 Crib, these and other contaminants are also detected beneath other cribs in the surrounding area. It is difficult to determine if the 216-A-10 Crib is affecting the groundwater quality because of the similarities in effluent constituents disposed at other cribs, the proximity of these numerous liquid effluent disposal sites to the 216-A-10 Crib, and the rapid rate of groundwater movement through the area.

4.8.5.1 Elevated Constituents. No contamination indicator parameter critical mean was exceeded in the 216-A-10 groundwater monitoring network during 1993. DWSs for the following constituents were regularly exceeded in the 216-A-10 network during 1993: tritium, nitrate, unfiltered chromium, and unfiltered iron (Barnett 1992, 1993; Kasza 1993a, 1993b). Exceedances also occurred for gross beta (DWS = 50 pCi/L) in well 299-E24-18 sampled 6/3/93, and for turbidity at wells 299-E17-20 and 299-E25-36 during the June 1993 sample collection. Requests for Analytical Data Evaluations were submitted for all unusual concentrations of constituents.

Table 4.8-2. Constituents Analyzed in the 216-A-10 Crib Groundwater Monitoring Network.

Contamination indicator parameters		
pH	Total organic carbon	
Specific conductance	Total organic halogen	
Groundwater quality parameters		
Chloride	Manganese	Sodium
Iron	Phenols	Sulfate
Drinking water parameters		
2,4-D	Endrin	Methoxychlor
2,4,5-TP Silvex	Fluoride	Nitrate
Arsenic	Gross alpha	Radium
Barium	Gross beta	Selenium
Cadmium	Lead	Silver
Chromium	Lindane	Toxaphene
Coliform bacteria	Mercury	Turbidity
Site-specific parameters		
1-butynol	Monobutyl phosphate	Tritium
Dibutyl phosphate	Tetrahydrofuran	Uranium
Gamma scan	Tributyl phosphate	

Nitrate concentrations (Figure 4.8-2) exceeded the DWS (45,000 ppb) at least once in all wells *except* 299-E24-18, and 299-E25-36 during 1993. The trend of the nitrate concentration in the groundwater beneath the 216-A-10 Facility is generally steady to slightly reduced since 1987, except in the upgradient well 299-E25-36. However, well 299-E25-36 is 430 m (1,400 ft) east-northeast of the 216-A-10 Crib. Although levels of nitrate in this upgradient well are rising, the nitrate standard has not been exceeded since the well was drilled in 1988.

Tritium concentrations (Figure 4.8-3) exceeded the DWS (20,000 pCi/L) at least once in all wells in the network *except* upgradient well 299-E25-36. All wells except the upgradient well show a decreasing trend in tritium concentrations since 1987 when discharges to the 216-A-10 Crib ended.

A discussion of the occurrence of high concentrations of unfiltered iron and chromium is presented in Section 2.2.4.

Figure 4.8-2. Nitrate Concentrations in the 216-A-10 Network Wells.

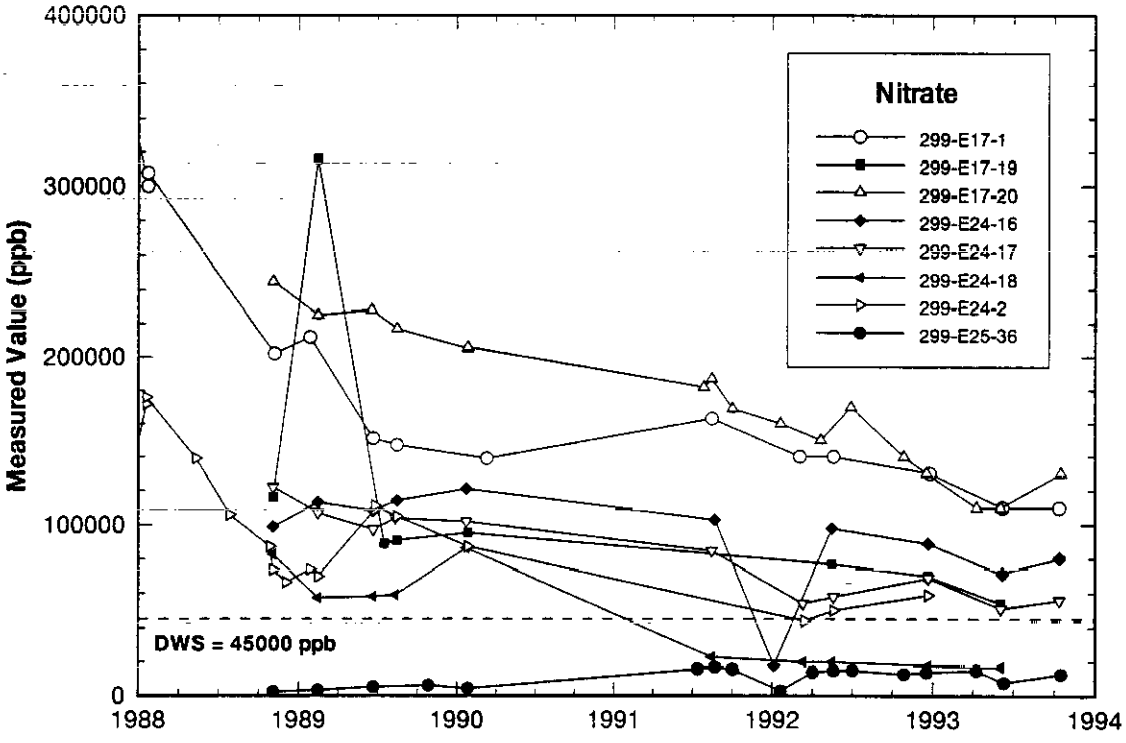
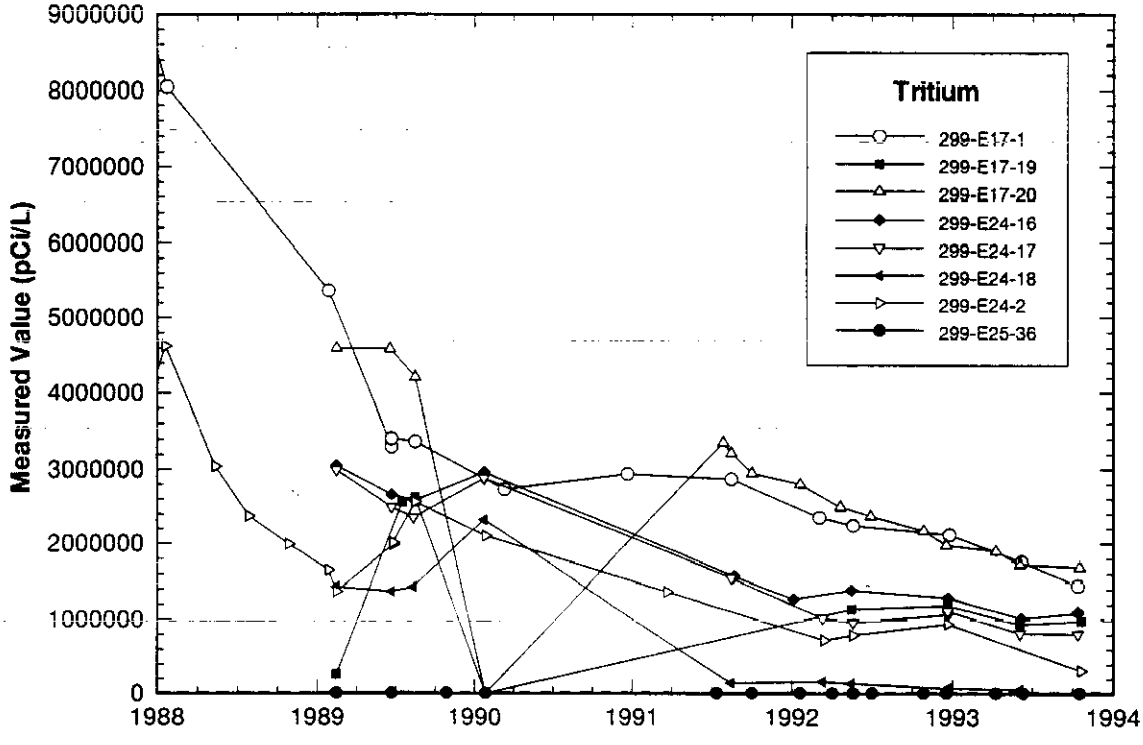


Figure 4.8-3. Tritium Concentrations in the 216-A-10 Network Wells.



4.8.5.2 Statistical Evaluation. During 1993, the quality of the groundwater beneath the 216-A-10 Crib was subjected to the required evaluation process for sites in indicator parameter evaluation status. Appendix C presents an explanation of the statistical evaluation method performed on the groundwater quality analytical results. The statistical evaluations of data for the past year at the 216-A-10 Crib consisted of comparisons between upgradient and downgradient wells for any indication of contamination in the groundwater underlying the facility. Statistical analyses required by 40 CFR 265.93(b) and *Washington Administrative Code* (WAC) 173-303-400 were performed on the samples collected from November 1988 to August 1989 for upgradient wells 299-E24-18 and 299-E25-36 (DOE-RL 1991). Results are presented in Table 4.8-3. This table lists the background average, background standard deviation, critical mean (or critical range, in the case of pH), and upgradient/downgradient comparison values for the four contamination indicator parameters. The critical mean (or critical range) is the value to which current and future averages of quadruplicate measurements are compared. None of the downgradient wells exceeded the contamination indicator parameter critical mean.

The data from the upgradient wells that were used to compute critical means came from a different laboratory than recent data. The comparability of recent indicator parameter data with historical data was evaluated to assess impacts of the change of analytical laboratory and the time gap observed between sampling events (DOE-RL 1991). The recent values of pH, specific conductance, and total organic carbon were all comparable to historical data. Total organic halogen will not be evaluated this year because of unsatisfactory audit findings (see Appendix A).

4.8.6 Groundwater Flow

4.8.6.1 Groundwater Flow Direction. Water levels in the 216-A-10 network were measured quarterly and during semiannual sampling events in 1993 (Barnett 1992, 1993; Kasza 1993a, 1993b). A composite hydrograph for data through September 1993 for all wells in the 216-A-10 network is presented in Figure 4.8-4. Water levels declined in all wells during the report period although an average is difficult to calculate due to several suspect water level measurements. The average water level decline in the A-10 monitoring well network was approximately 0.15 m (0.5 ft) between June 1992 and June 1993. This trend in declining water levels is a continuation of a longer term decline that became evident during 1988 and 1989, following the end of PUREX Plant operations and cessation of discharges to the 216-A-10 Crib and other nearby liquid effluent disposal facilities.

Groundwater flow in the vicinity of the 216-A-10 Crib is poorly defined because the local hydraulic gradient is extremely low (Figures 4.8-1 and 4.8-5) and the quality of measurement data are occasionally suspect. Based on the regional water table maps (see Figures 2-4 and 4.1-13), groundwater flow is toward the south to southeast.

4.8.6.2 Rate of Flow. Regional hydraulic head gradient is estimated to be in the range of 0.0001 to 0.0002 (WHC 1992). Based on these gradient estimates and estimates of hydraulic conductivity (150 to 300 m/day [500 to

Table 4.8-3. Critical Means Table for 24 Comparisons--Background Contamination Indicator Parameter Data for the 216-A-10 Crib.[a,b]

Constituent (unit)	n	df	t_c	Average background	Standard deviation	Critical mean	Upgradient/ downgradient comparison value
Specific conductance (μmho/cm)	8	7	5.5799	273.31	77.643	732.8	732.8
Field pH	8	7	6.2684	8.0241	0.319	[5.90, 10.14]	[5.90, 10.14]
Total organic carbon[c] (ppb)	8	7	5.5799	618.75	117.83	1,316.1	1,316.1
Total organic halogen[d] (ppb)	8	7	5.5799	4.47	1.544	13.6	NC[e]

[a]Data collected from November 1988 to August 1989 for upgradient wells 2-E24-18 and 2-E25-36. Values calculated based on 24 comparisons.

[b]The following notations are used in this table:

df = degrees of freedom (n-1)
n = number of background replicate averages
t_c = Bonferroni critical t-value for appropriate df and 24 comparisons.

[c]Critical mean were calculated from values reported below the contractually required quantitation limits (DOE-RL 1991).

[d]Critical mean were calculated using data analyzed by U.S. Testing, Inc., Richland, Washington.

[e]Upgradient/downgradient comparison value for total organic halogen cannot be established because problems associated with data quality preclude the determination of total organic halogen limit of quantitation.

NC = not calculated.

1,000 ft/day]) and porosity (0.25) for the unconfined aquifer near the 216-A-10 Crib (WHC 1992), groundwater flow velocities may range from 0.06 to 0.2 m/day (0.2 to 0.8 ft/day). Regional-scale water table elevation changes suggest that local groundwater flow is generally toward the south or southeast. Tritium plume maps also indicate that groundwater flow in the southern half of the 200 East Area is directed to the southeast (WHC 1992).

It is not possible to determine any vertical groundwater gradient because there are no paired (shallow and deep) well completions in the immediate vicinity.

Figure 4.8-4. Composite Hydrograph for the 216-A-10 Network Wells.

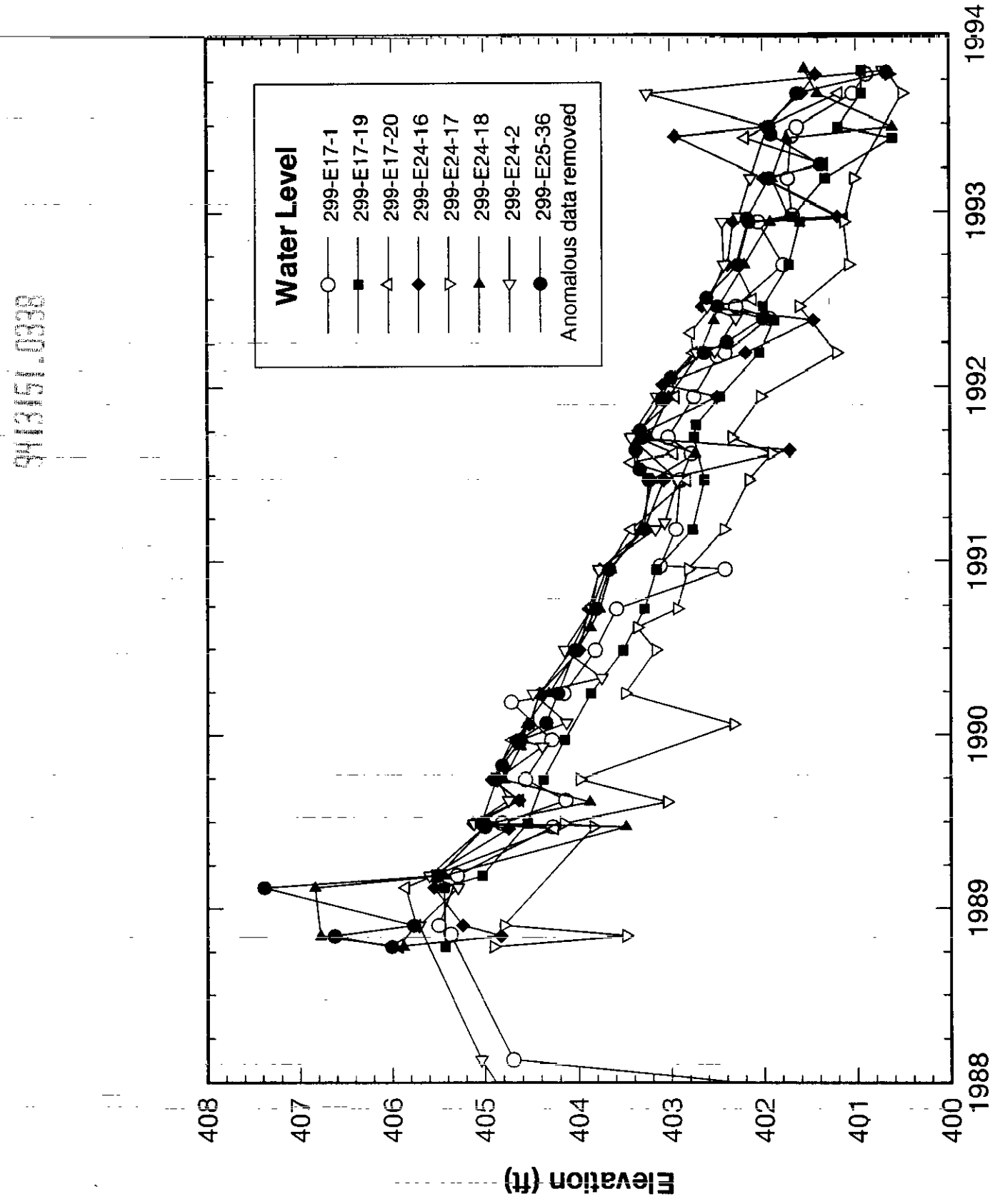
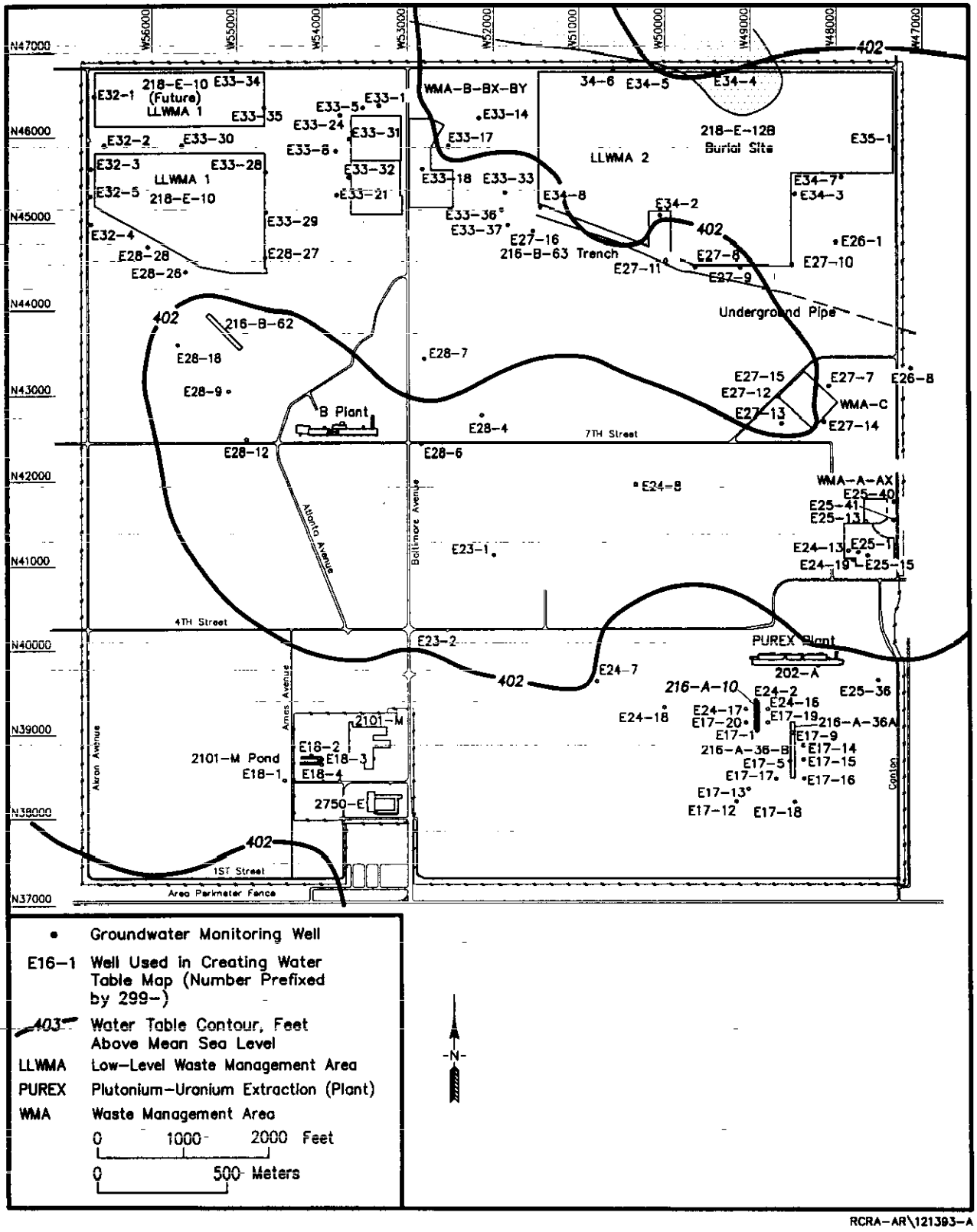


Figure 4.8-5. 200 East Area and 216-A-10 Crib Vicinity Water Table Map, June 1993.



4.8.6.3 Evaluation of Monitoring Well Network. Water levels are measured regularly and the adequacy of the existing monitoring network is evaluated accordingly. The water level in each well is compared to the depth of the screened interval and pump intake to ensure that sufficient volumes of water exist for sampling purposes. As stated in Section 4.8.2, there is no near-term need to replace any of the existing groundwater monitoring wells. Because the 216-A-10 Crib is surrounded on all sides by six groundwater monitoring wells, the downgradient monitoring network is currently adequate to monitor the groundwater quality beneath the crib.

Because of the low hydraulic gradient and continuing decline of the regional water table, the evaluation of the suitability of the upgradient wells is difficult. Wells 299-E24-18 and 299-E25-36 were selected when the monitoring well network was established (1988) to determine the groundwater quality in the most probable upgradient directions from the facility. Measurement errors, undetected surveying errors, and daily water level fluctuations affect the accuracy of reported water levels and the estimates of flow direction and head. As Figure 4.8-4 illustrates, it is currently difficult to assign relative positions (upgradient or downgradient) for some wells, because very small changes in water levels may constitute a reversal in gradient. The selection of the upgradient well(s) for the 216-A-10 groundwater monitoring network may not be appropriate in light of the current water table configuration and requires re-evaluation.

4.8.7 References

40 CFR 264, "Standards for Owners and Operators of Permitted Hazardous Waste Facilities," *Code of Federal Regulations*, as amended.

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4.9 216-B-63 TRENCH

M. D. Sweeney
Westinghouse Hanford Company

4.9.1 Overview of the Facility

The 216-B-63 Trench, in service from March 1970 to February 1992, received liquid effluent [378,540 to 1,514,160 L/d (100,000 to 400,000 gal/d)] from the B Plant chemical sewer. The liquid effluent was a 70/30 mixture of steam condensate and raw water, which was disposed to the west end of the open, unlined earthen trench. Past releases to the trench included radioactive and dangerous waste. Documented hazardous discharges occurred from 1970 to October 1985, and consisted of aqueous sulfuric acid and sodium hydroxide solutions that exceeded pH values of 2.0 and 12.5, respectively. Radioactive soils were dredged from the trench in August 1970, but no records exist of radioactive waste disposal to the trench. Starting in 1985, physical controls, radiation monitors, and operating procedures were modified to avoid inadvertent discharge of chemicals or radioactive substances to the wastewater stream. Although liquid effluent discharge to the 216-B-63 Trench ceased permanently in February 1992, the trench will be maintained for B Plant discharges in the event of an emergency.

A *Resource Conservation and Recovery Act of 1976* (RCRA) indicator evaluation groundwater monitoring network is being established under guidelines established in the RCRA interim-status groundwater monitoring plan for the 216-B-63 Trench (PNL 1989) and in accordance with the *Hanford Federal Facility Agreement and Consent Order* Milestone M-20-38 (Ecology et al. 1992). This network operates under RCRA interim-status regulations (40 *Code of Federal Regulations* [CFR] 265). Until February 1992 the 216-B-63 Trench received wastewater from the B Plant located in the 200 East Area (see Figure 1-1, Chapter 1.0). This wastewater contained dangerous waste and materials. Because the 216-B-63 Trench is not expected to receive additional effluent, the U.S. Department of Energy (DOE), Richland Operations Office (RL) has proposed that the trench be closed under RCRA interim-status regulations (40 CFR 265). A closure plan for the 216-B-63 Trench is due to be submitted in May 1996.

The 216-B-63 Trench lies at an elevation of about 195 m (640 ft) along the northern flank of Cold Creek bar. Cold Creek bar was formed along the margin of a Pleistocene cataclysmic flood channel located in the northeastern portion of the 200 East Area (see Figure 4.1-1, Section 4.1). The land surface in the vicinity of the trench dips at ~44 m/mi (~145 ft/mi) (<2°) to the northeast, toward the axis of the paleochannel.

Essentially, only a single stratigraphic unit, the Hanford formation, overlies basalt beneath the site. The sediments directly beneath the 216-B-63 Trench appear to be mostly mixtures of sand and gravel associated with high-energy deposition by cataclysmic floods. Lateral facies changes occur in the flood deposits to the south and west, however, away from the axis of the main flood channel. Along the southern margin of the flood channel,

deposits become finer grained and include fine sand, silt, and occasionally mud strata, which could act locally as aquitards leading to perched water conditions.

The sediments overlying the basalt become progressively thinner to the northeast. The sediments are 76 to 79 m (250 to 260 ft) thick beneath the trench. The thickness of the saturated zone varies from 0.15 to 2 m (0.5 to 7 ft). The water table varies from 59 to 61 m (195 to 200 ft) below ground surface.

4.9.2 Summary of 1993 RCRA Activities

The 12 wells in the monitoring network were sampled between December 1992 and June 1993 for contamination indicator, groundwater quality, and drinking water quality parameters, as well as uranium, tritium, gamma scan, and volatile organic compounds. Results of these sampling event analyses are discussed in Section 4.9.3. More detailed discussions of this site were included in each of the four quarterly reports (e.g., DOE-RL 1994).

Monthly water level measurements of the four-well monitoring network were made from October 1992 through September 1993, in addition to routine water level measurements made at the time of sampling.

4.9.3 Sampling and Analysis Program

The current groundwater monitoring network consists of 12 wells (Table 4.9-1). The well locations are shown in Figure 4.9-1. The monitoring network conforms to the groundwater monitoring plan for 216-B-63 Trench (PNL 1989).

Several quarters of groundwater chemistry data are available for most of the 216-B-63 groundwater monitoring wells for fiscal year 1993. The wells have been sampled for contamination indicator parameters, drinking water standards (DWS), groundwater quality parameters, and site-specific parameters as identified in Table 4.9-2. Site-specific parameters were selected based on a history of waste disposed of at this site and in surrounding waste management areas.

4.9.4 Groundwater Chemistry

Groundwater chemistry samples were collected for most wells within the 216-B-63 groundwater monitoring network during 1993. Only two 216-B-63 wells (299-E27-18 and 299-E27-19) were sampled all four quarters in fiscal year 1993. The remaining wells continued to be sampled on a semiannual schedule.

4.9.4.1 Constituents of Concern. At the present time, there are no dangerous or radioactive constituents in the groundwater. During 1993, constituents detected consistently above DWSs within the 216-B-63 monitoring network

Table 4.9-1. 216-B-63 Groundwater Monitoring Network.

Well	Aquifer	Sampling frequency	Water levels	Well standard	Other networks
299-E27-11[89]	Top of unconfined	S	Q	RCRA	LLWMA-2
299-E27-16[90]	Top of unconfined	S	Q	RCRA	--
299-E27-8[87]	Top of unconfined	S	Q	RCRA	LLWMA-2
299-E27-9[87]	Top of unconfined	S	Q	RCRA	LLWMA-2
299-E33-33[90]	Top of unconfined	S	Q	RCRA	SST B-BX-BY
299-E33-36[90]	Top of unconfined	S	Q	RCRA	--
299-E33-37[90]	Top of unconfined	S	Q	RCRA	--
299-E34-8[90]	Top of unconfined	S	Q	RCRA	LLWMA-2
299-E34-10[91]	Top of unconfined	S	Q	RCRA	LLWMA-2
299-E27-17[91]	Top of unconfined	S	Q	RCRA	LLWMA-2
299-E27-18[92]	Top of unconfined	S	Q	RCRA	--
299-E27-19[92]	Top of unconfined	S	Q	RCRA	--

Notes: Shading denotes upgradient wells. Superscript following well number denotes the year of installation.
LLWMA = Low-Level Waste Management Area.
Q = frequency on a quarterly basis.
RCRA = well is constructed to RCRA-specified standards.
S = frequency on a semiannual basis.

include unfiltered iron and chromium. All remaining constituents that occurred above the DWS (i.e., coliform bacteria, turbidity) occurred sporadically among several wells at different times, suggesting suspicious data. The quality of these data are being evaluated. These constituents will be closely monitored and evaluated in subsequent quarterly reports. Elevated levels of unfiltered iron and chromium (Figures 4.9-2 and 4.9-3) appear to be derived from well construction practices rather than from groundwater (see Section 2.2.4). This is indicated by filtered samples, which generally are near or below the contractually required quantitation limit for these constituents (Figures 4.9-4 and 4.9-5).

4.9.4.2 Statistical Evaluation. The four quarters of sampling required for evaluation of background parameters has been completed for the 216-B-63 Ditch. The statistical methods used to establish initial background levels are discussed in Appendix C. The background parameters were evaluated and critical means for each were calculated (with the exception of total organic halogen; see Appendix A) and are presented in Table 4.9-3. Downgradient wells did not exceed control limits for any quarter in 1993. Well 299-E27-8 did have a pH exceedance for field-generated data but laboratory pH results were within the critical mean for this parameter.

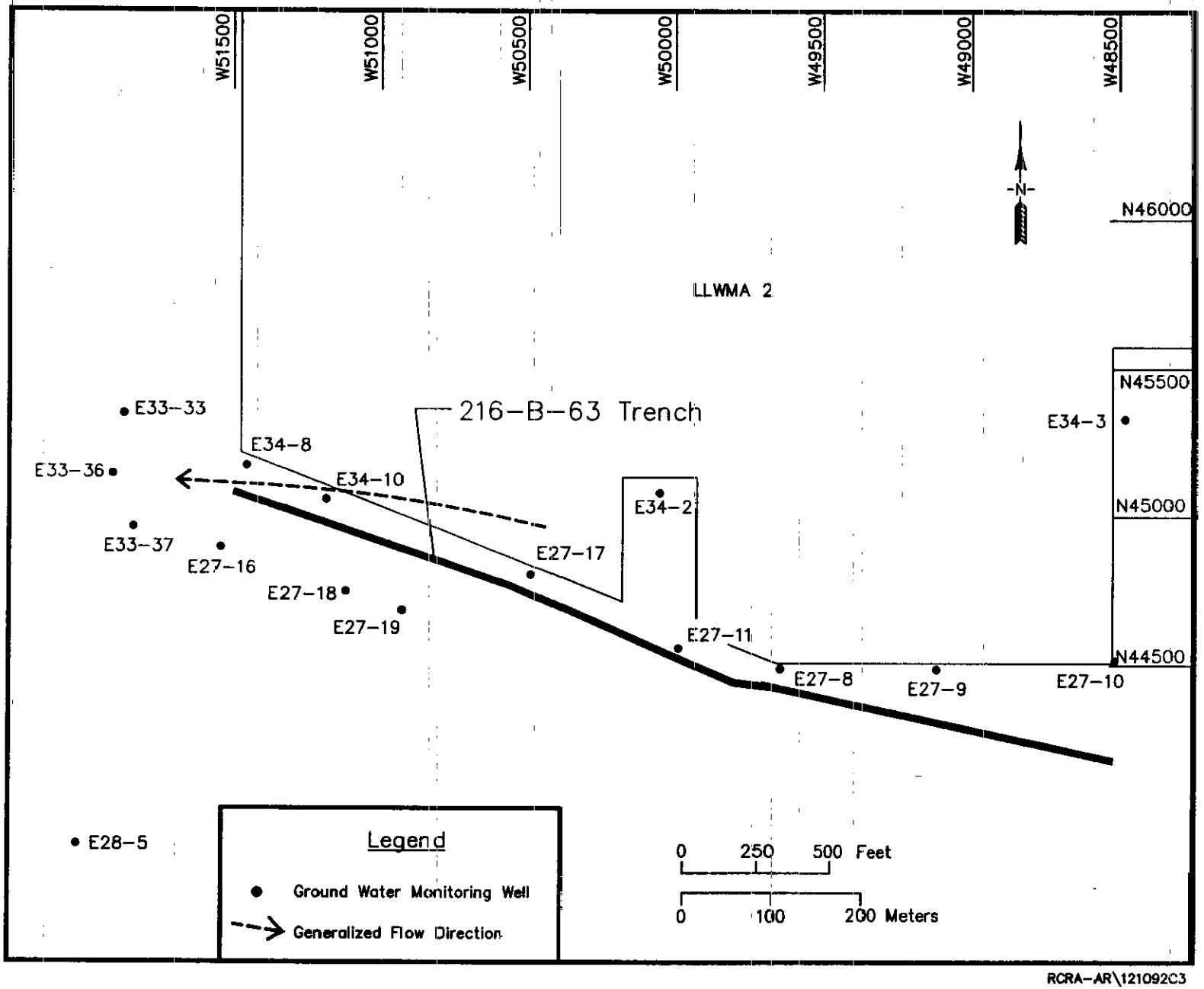


Figure 4.9-1. Monitoring Well Locations for the 216-B-63 Trench.

Table 4.9-2. Constituent List for the 216-B-63 Trench Monitoring Network.

Contamination indicator parameters		
pH	Total organic carbon	
Specific conductance	Total organic halogen	
Groundwater quality parameters		
Chloride	Manganese	Sodium
Iron	Phenols	Sulfate
Drinking water parameters		
2,4-D	Endrin	Methoxychlor
2,4,5-TP Silvex	Fluoride	Nitrate
Arsenic	Gross alpha	Radium
Barium	Gross beta	Selenium
Cadmium	Lead	Silver
Chromium	Lindane	Toxaphene
Coliform bacteria	Mercury	Turbidity
Site-specific parameters		
Gamma scan	Sulfate	Uranium
Sodium	Tritium	Volatile organic analysis

4.9.5 Groundwater Flow

4.9.5.1 Groundwater Flow Direction. In general, groundwater levels continued to decline in 1993 (Figure 4.9-6). Water levels are recorded quarterly and during sample collection. These data are reported in previous quarterly reports of RCRA groundwater monitoring data (DOE-RL 1994). A water table map of the 200 Areas for June 1993 is presented in Figure 4.1-13, Section 4.1. Water table elevations reveal a westward flow direction that roughly parallels the trend of the 216-B-63 Trench (Williams 1992). A significantly steeper gradient than that observed for the region (Williams 1992), is still apparent based on an anomalously low water level reading measured at the west end of the trench in well 299-E33-36. The elevation of this well is considered suspect and will be resurveyed during the next quarter.

4.9.5.2 Rate of Flow. The horizontal groundwater gradient in the unconfined aquifer under the 216-B-63 Trench is approximately 6.7×10^{-5} between wells 299-E27-9 and 299-E33-33 in 1993. Applying this estimated gradient to a form of Darcy's law

$$v = \frac{(Ki)}{n} \qquad (1)$$

Figure 4.9-2. Unfiltered Iron Versus Time Plot for Several 216-B-63 Wells.

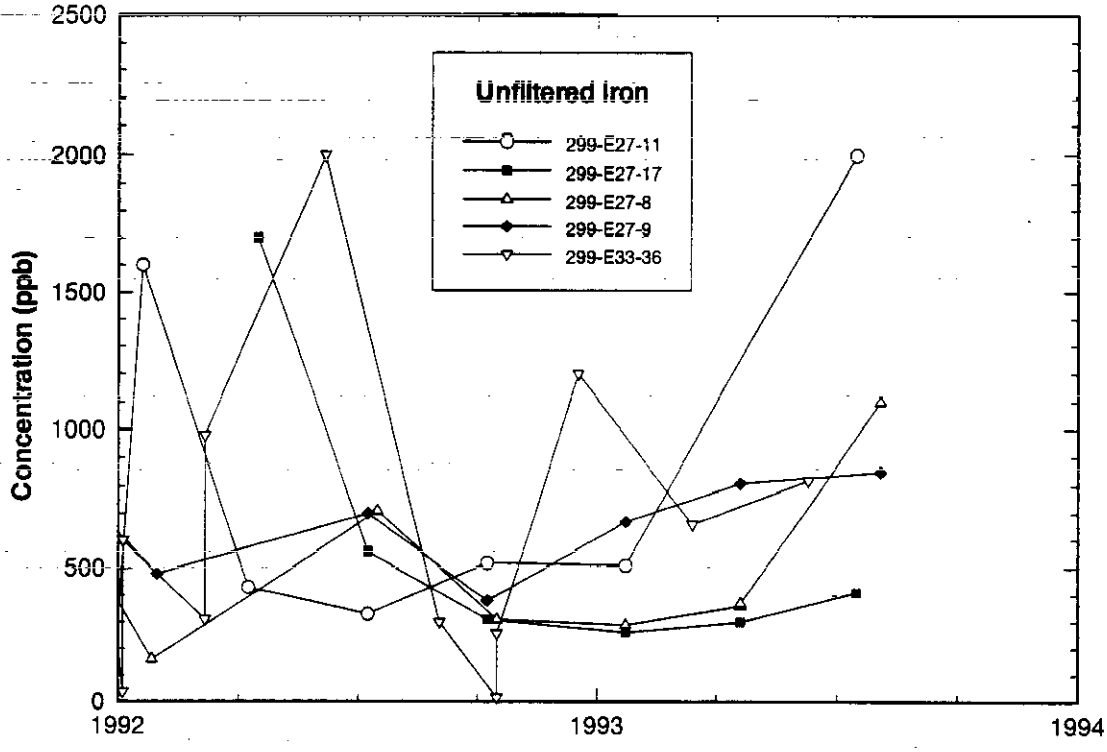


Figure 4.9-3. Unfiltered Chromium Versus Time Plot for Several 216-B-63 Wells.

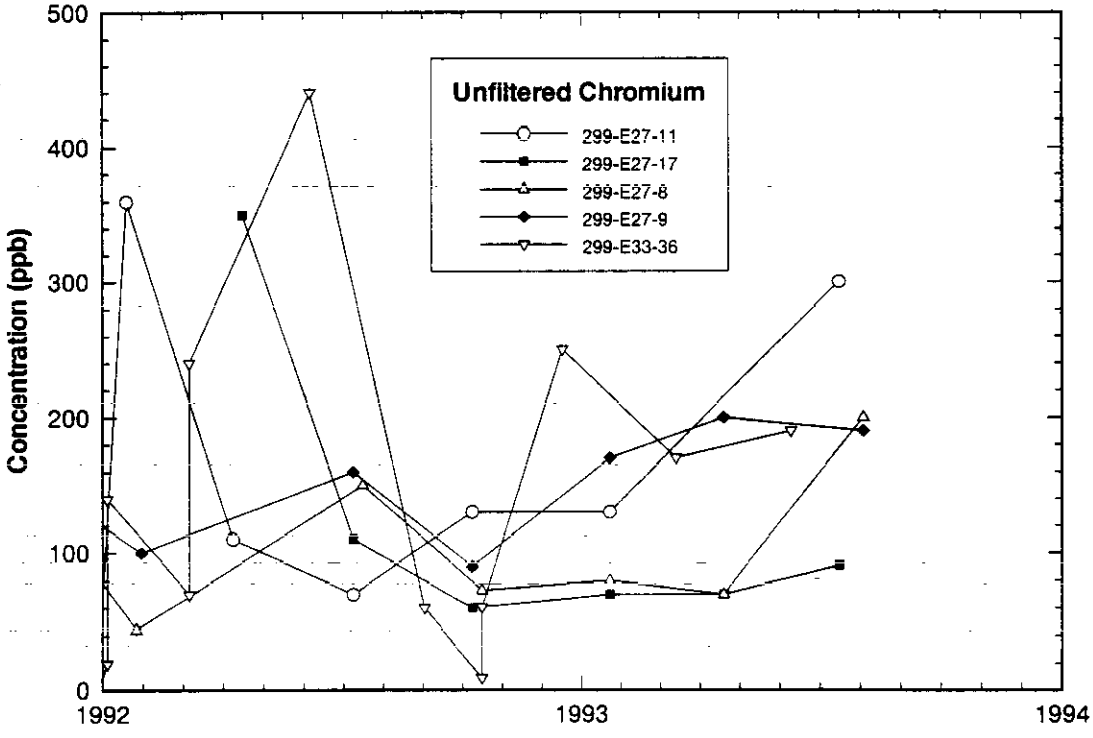


Figure 4.9-4. Filtered Iron Versus Time Plot for Several 216-B-63 Wells.

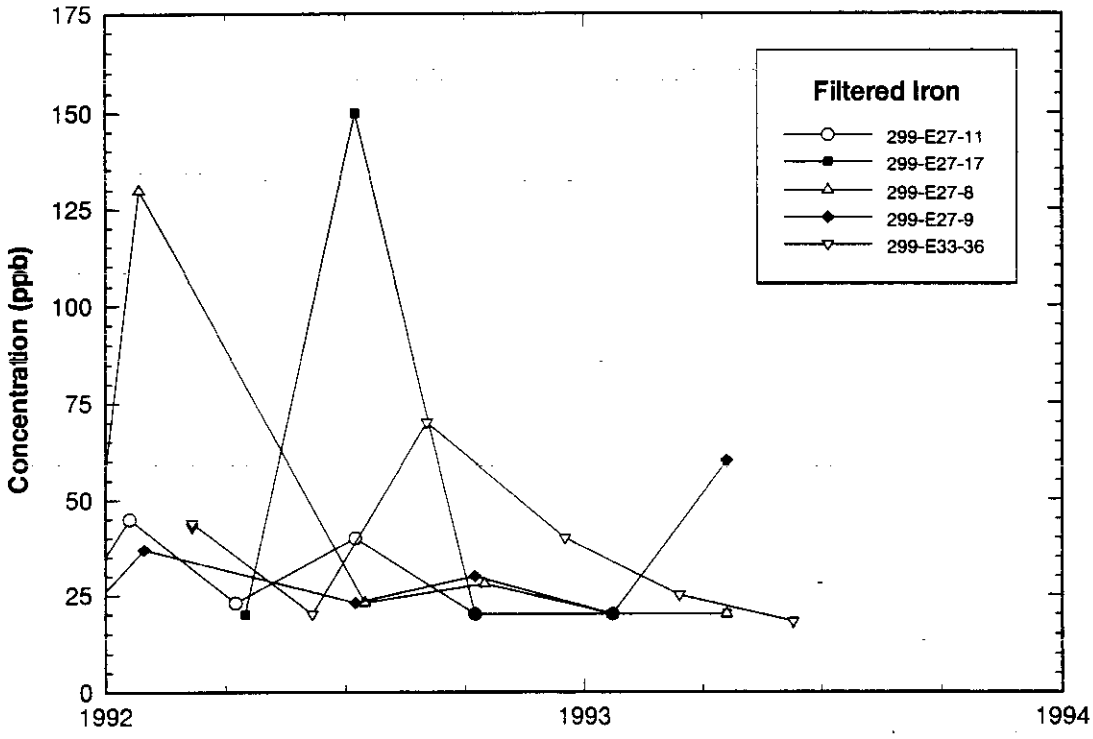


Figure 4.9-5. Filtered Chromium Versus Time Plot for Several 216-B-63 Wells.

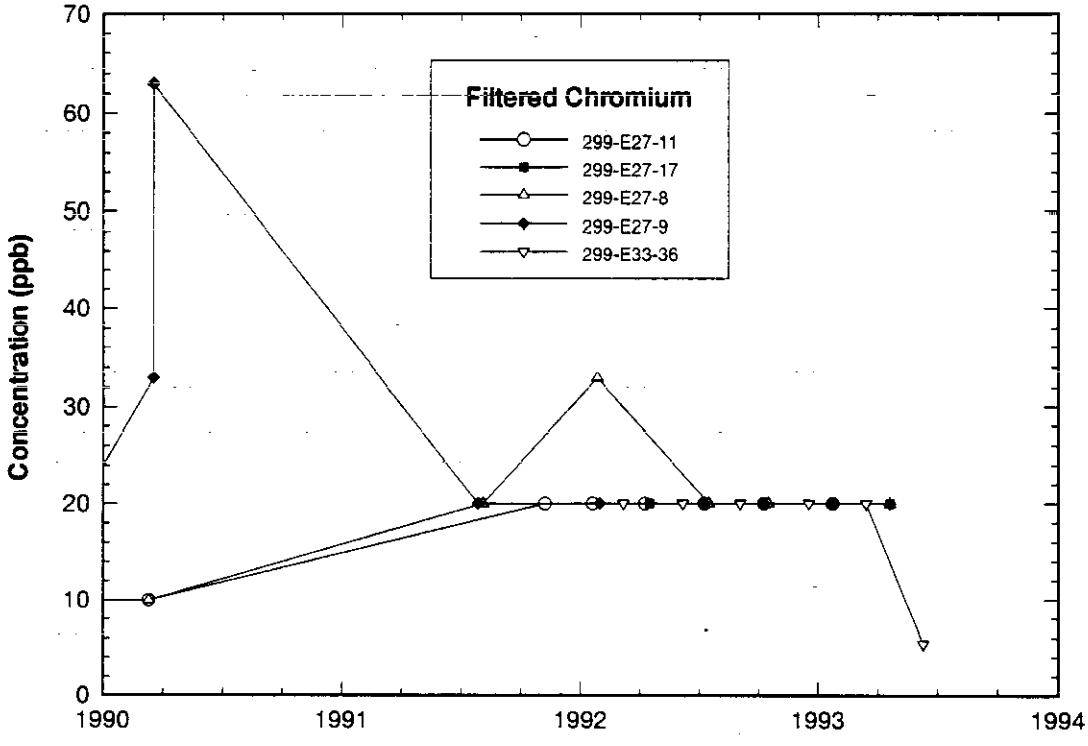


Table 4.9-3. Critical Means Table for 48 Comparisons--Background Contamination Indicator Parameter Data for the 216-B-63 Trench.[a,b]

Constituent (unit)	n	df	t_c	Average background	Standard deviation	Critical mean	Upgradient/ downgradient comparison value
Specific conductance (μmho/cm)	21	20	4.224	369.393	60.192	629.6	629.6
Field pH	20	19	4.572	7.975	0.190	[7.08, 8.87]	[7.08, 8.87]
Total organic carbon[c] (ppb)	20	19	4.267	500	NC	NC	1,400[e]
Total organic halogen[d] (ppb)	NC	NC	NC	NC	NC	NC	NC

[a]Data collected from July 1992 to April 1993 for upgradient wells 2-E27-8, 2-E27-9, 2-E34-10, and 2-E27-17. Data collected from July 1992 to July 1993 for upgradient well 2-E27-11. Values calculated based on 48 comparisons.

[b]The following notations are used in this table:

df = degrees of freedom (n-1)
n = number of background replicate averages
t_c = Bonferroni critical t-value for appropriate df and 48 comparisons.

[c]Critical mean cannot be calculated because of lack of an estimate of background standard deviation.

[d]Critical mean cannot be calculated because of problems associated with data quality.

[e]Upgradient/downgradient comparison value for total organic carbon is the limit of quantitation based on 1993 field blanks data (see Appendix A).

NC = not calculated.

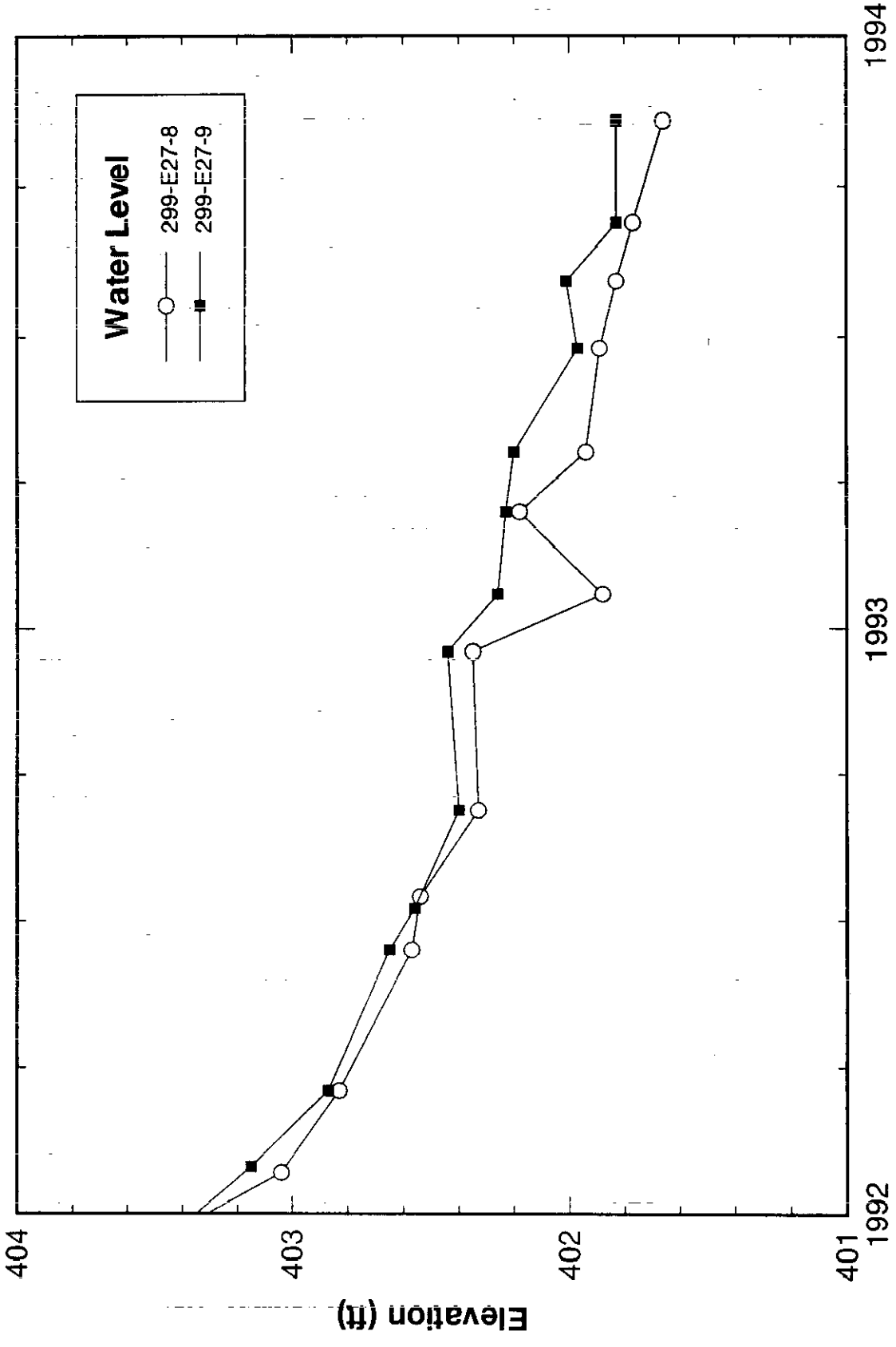
where:

v = Average linear velocity in m/d (ft/d)
K = Hydraulic conductivity in m/d (ft/d)
i = Hydraulic gradient (dimensionless)
n = Effective porosity (dimensionless).

The calculations of groundwater velocity assume horizontal flow and a homogeneous aquifer. The following inputs from slug test data were used to determine the velocity near well 299-E34-8:

K = 182 m/d (596 ft/d)
i = 6.7×10^{-5}
n = 0.20 (Graham et al. 1981).

Figure 4.9-6. Hydrographs of Water Level Measurements (Feet Above Sea Level) for 216-B-63 Wells.



The given value of K is representative of the Hanford formation, based on pump tests in the 200 Areas (see Figure 4.1-15, Section 4.1). The calculated velocity is 0.06 m/d (0.2 ft/day).

4.9.5.3 Monitoring Well Network. Based on the MEMO groundwater modeling program (Jackson et al. 1991), the existing network should provide a monitoring efficiency of 66 to 85% for the 216-B-63 Trench. The 66% monitoring efficiency results from a flow-direction azimuth of 270° (toward the west), while an 85% monitoring efficiency is associated with a 225° azimuth flow direction (toward the southwest).

The current network is composed of six wells drilled specifically to monitor the 216-B-63 Trench. The network also includes five wells drilled to monitor the Low-Level Burial Grounds located just north of the 216-B-63 Trench (upgradient), and one well drilled to monitor the single-shell tanks (upgradient). Currently the network is considered adequate but will be continuously evaluated as water levels and groundwater gradients change throughout time.

Water level elevations recorded for well 299-E33-36 may be in error. Resurveying of the network is presently underway to determine if vertical control errors were made during the initial survey of this well.

4.9.6 References

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4.10 200 EAST AREA LIQUID EFFLUENT RETENTION FACILITY

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4.10.1 Overview of the Facility

The Liquid Effluent Retention Facility (LERF) consists of four 24.6 x 10^6-L (6.5-Mgal) surface impoundments (basins), located on a 15.8-ha (39-acre) site northeast of the 200 East Area on the Hanford Site (Figure 4.10-1). Three of the basins were constructed of two composite liners, a leachate collection system between the liners, and floating covers. The fourth basin has been excavated but has not been completed and will not be used for 242-A Evaporator effluent.

The 242-A Evaporator was used to treat double-shell tank (DST) waste. Effluent from the 242-A Evaporator was discharged to cribs in the 200 East Area. The evaporator was shut down when listed waste was found in the effluent stream. Plans to restart the 242-A Evaporator are being made. The LERF will act as a temporary storage facility until an effluent treatment system is operational.

The waste stored in the LERF will be a dilute, aqueous mixed waste stream generated from the treatment of the DST waste by the 242-A Evaporator. Key constituents detected in the effluent stream from the 242-A Evaporator have been acetone, aluminum, 1-butanol, 2-butanone, tritium, ^{90}Sr, ^{106}Ru, and ^{137}Cs. Further information on the effect on groundwater from release of this waste stream is documented in the *Liquid Effluent Study Final Report* (WHC 1990).

A groundwater monitoring network has been established for the LERF (WHC 1991). The LERF will receive and store 242-A Evaporator process condensate effluent, which is a mixed waste. The 242-A Evaporator process condensate effluent is regulated as a dangerous waste under *Washington Administrative Code* (WAC) 173-303 because of the toxicity of the ammonia and the presence of listed waste constituents. An interim-status groundwater monitoring system is required to determine existing groundwater quality at the LERF site until a final permit has been approved (40 *Code of Federal Regulations* [CFR] 265).

Four wells have been constructed and are used to monitor groundwater levels and water quality. Data from these wells were used to establish initial background groundwater quality.

A dangerous waste permit application (DOE-RL 1991) was submitted for review in June 1991. No response on the application has been received. Refer to Section 4.1 for overview of 200 Areas geology.

4.10.2 Summary of 1993 RCRA Activities

The three wells in the monitoring network were sampled in December 1992 and June 1993 for contamination indicator, groundwater quality, and drinking water quality parameters, as well as uranium, tritium, gamma scan, and

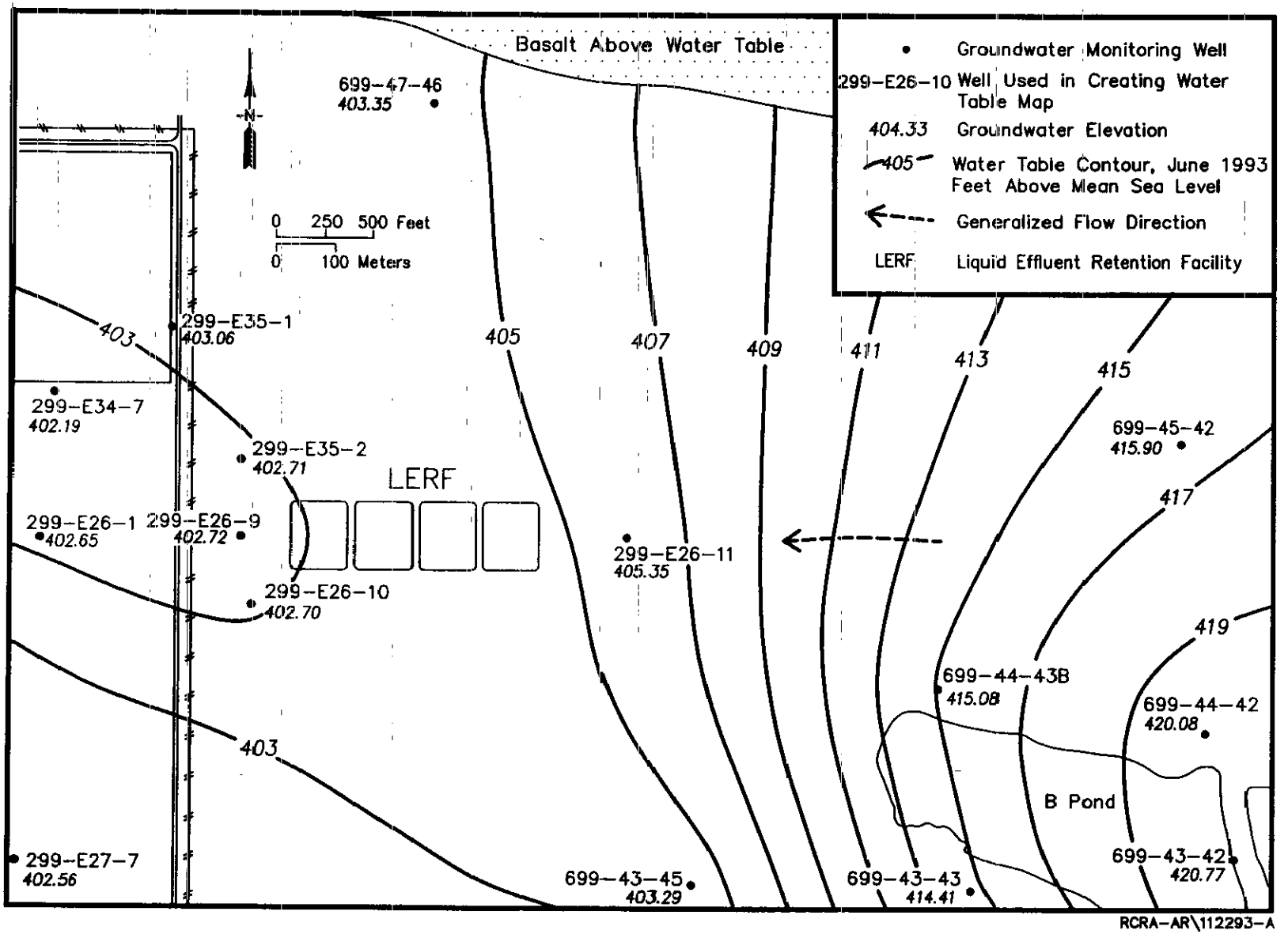


Figure 4.10-1. Monitoring Well Locations for the Liquid Effluent Retention Facility.

volatile organic analysis. One well in the monitoring network has gone dry. Results of these sampling event analyses are discussed in Section 4.10.3. More detailed discussions of this site were included in each of the four quarterly reports (e.g., DOE-RL 1994).

Monthly water level measurements of the four-well monitoring network were made from October 1992 through September 1993, in addition to routine water level measurements made at the time of sampling.

The three remaining wells that intercept water within the current monitoring network completed quarterly sampling in 1993. One well in the network went dry during 1993. Background values have been established for detection-level indicator parameters. Water level measurements were taken quarterly and at the time of sampling during 1993.

4.10.3 Sampling and Analysis Program

The current groundwater monitoring network consists of four wells (Table 4.10-1). The well locations are shown in Figure 4.10-1.

Several quarters of groundwater chemistry data are available for most of the LERF groundwater monitoring wells for fiscal year 1993. The wells have been sampled for contamination indicator parameters, drinking water standards (DWS), groundwater quality parameters, and site-specific parameters as identified in Table 4.10-2. Site-specific parameters were selected based on a history of waste disposed in surrounding waste management areas and on proposed waste characteristics for the effluents targeted for LERF.

4.10.4 Groundwater Chemistry

Groundwater chemistry samples were collected for most wells within the LERF groundwater monitoring network during 1993. Only one well could not be sampled for all four quarters in 1993. Well 299-E26-9 has been taken off of the sampling schedule due to the low water level in the well casing (0.15 m [0.5 ft]).

4.10.4.1 Constituents of Concern. During 1993, constituents detected above DWSs within the LERF monitoring network include unfiltered iron and chromium. Constituents monitored during semiannual sampling at the LERF are listed in Table 4.10-3. Elevated levels of unfiltered iron and chromium (Figures 4.10-2 and 4.10-3) appear to be derived from well construction practices rather than from groundwater (see Section 2.2.4).

4.10.4.2 Statistical Evaluation. Statistical evaluation of data for the past year at the LERF consisted of comparisons between the upgradient and downgradient wells for any indication of contamination in the groundwater beneath the facility. The statistical methods used to establish initial background levels are discussed in Appendix C. One of the downgradient wells (299-E26-9) has gone dry and has been removed from the sampling schedule and is not included in the statistical evaluation.

Table 4.10-1. Liquid Effluent Retention Facility Groundwater Monitoring Network.

Well	Aquifer	Sampling frequency	Water levels	Well standard	Other networks
299-E26-11[89]	Top of unconfined	S	Q	RCRA	--
299-E26-10[90]	Top of unconfined	S	Q	RCRA	--
299-E26-9[87]	Top of unconfined	S[a]	Q	RCRA	--
299-E35-2[87]	Top of unconfined	S	Q	RCRA	--

Notes: Shading denotes upgradient wells. Superscript following well number denotes the year of installation.
[a]Taken off sampling schedule (see text).
Q = frequency on a quarterly basis.
RCRA = well is constructed to RCRA-specified standards.
S = frequency on a semiannual basis.

Table 4.10-2. Constituent List for the Liquid Effluent Retention Facility Monitoring Network.

Contamination indicator parameters		
pH	Total organic carbon	
Specific conductance	Total organic halogen	
Groundwater quality parameters		
Chloride	Manganese	Sodium
Iron	Phenols	Sulfate
Drinking water parameters		
2,4-D	Endrin	Methoxychlor
2,4,5-TP Silvex	Fluoride	Nitrate
Arsenic	Gross alpha	Radium
Barium	Gross beta	Selenium
Cadmium	Lead	Silver
Chromium	Lindane	Toxaphene
Coliform bacteria	Mercury	Turbidity
Site-specific parameters		
Gamma scan	Uranium	Volatile organic analysis
Tritium		

Table 4.10-3. Critical Means Table for 12 Comparisons--Background Contamination Indicator Parameter Data for the Liquid Effluent Retention Facility.[a,b]

Constituent (unit)	n	df	t_c	Average background	Standard deviation	Critical mean	Upgradient/ downgradient comparison value
Specific conductance (μmho/cm)	4	3	10.869	332.125	11.736	474.7	474.7
Field pH	4	3	13.745	7.742	0.311	[2.96, 12.52]	[6.32, 9.36][e]
Total organic carbon[c] (ppb)	4	3	10.869	718.75	295.364	4,308	4,308
Total organic halogen[d] (ppb)	NC	NC	NC	NC	NC	NC	NC

[a]Data collected from June 1991 to April 1992 for upgradient well 2-E26-11. Values calculated based on 12 comparisons.

[b]The following notations are used in this table:

df = degrees of freedom (n-1)
n = number of background replicate averages
t_c = Bonferroni critical t-value for appropriate df and 12 comparisons.

[c]Critical mean was calculated from values reported below the contractually required quantitation limit.

[d]Critical mean cannot be calculated because of problems associated with data quality.

[e]Upgradient/downgradient comparison values for pH were calculated using data from June 1991 to October 1993 (well 2-E26-11) because the critical range calculated using four quarters of data is too large to be meaningful.

NC = not calculated.

Statistical evaluation required by 40 CFR 265.93(b) and WAC 173-303-400 were performed on samples collected from June 1991 to April 1992 for the upgradient well listed in Table 4.10-1. Results are presented in Table 4.10-3. Total organic halogen is not evaluated due to problems associated with data quality (see Appendix A). For the LERF, the critical range for pH was too large to be meaningful. An alternate range for upgradient/downgradient comparisons was calculated using upgradient data collected from June 1991 to October 1993 (see Appendix C). Downgradient wells did not exceed control limits for any quarter in 1993.

Figure 4.10-2. Unfiltered Iron Versus Time Plot for Several Liquid Effluent Retention Facility Wells.

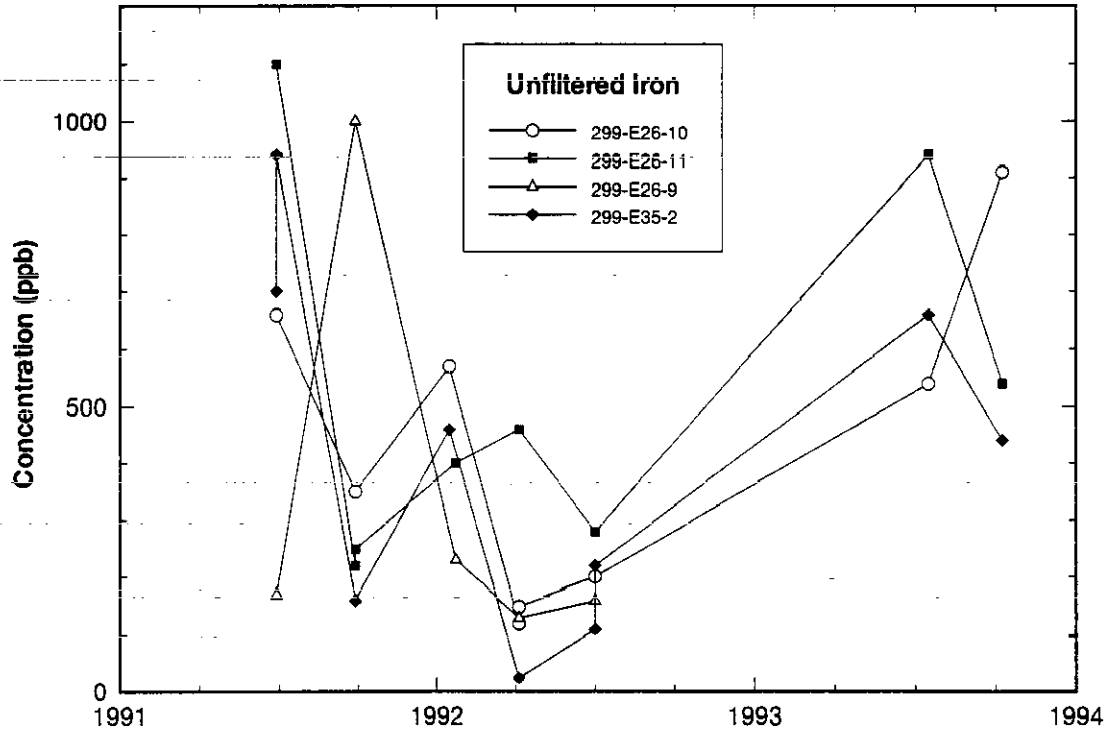
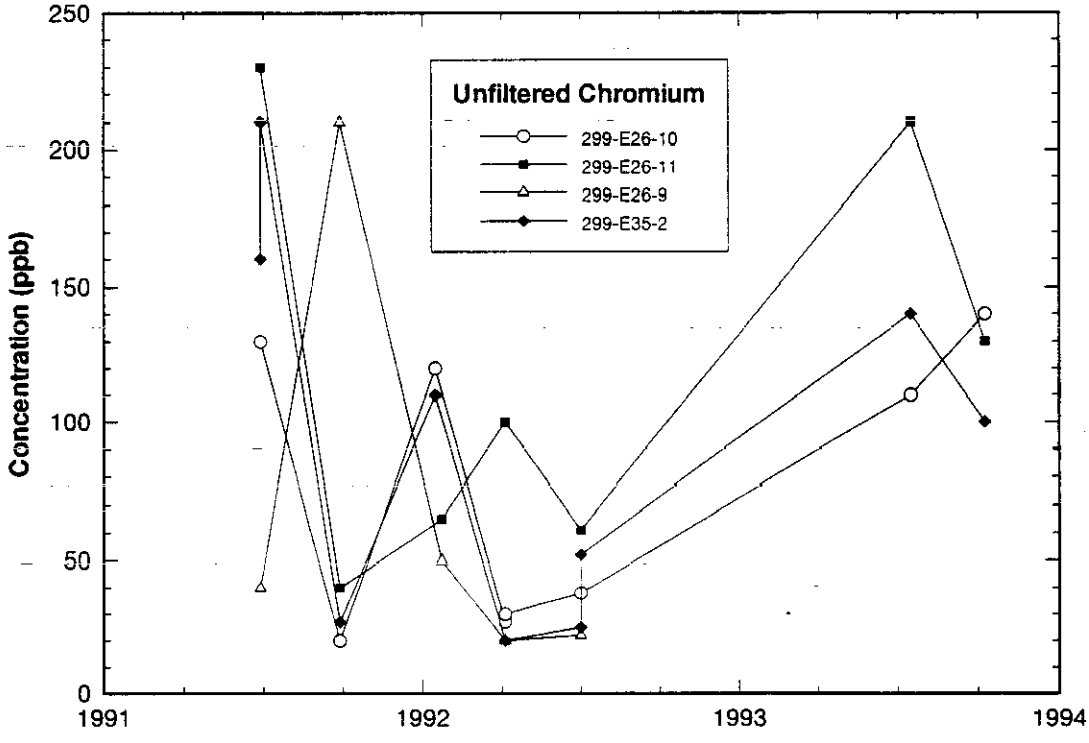


Figure 4.10-3. Unfiltered Chromium Versus Time Plot for Several Liquid Effluent Retention Facility Wells.



4.10.5 Groundwater Flow

4.10.5.1 Groundwater Flow Direction. In general, groundwater levels between the LERF continued to decline in 1993 (Figure 4.10-4). Water levels are recorded quarterly and during sample collection. These data are reported in previous quarterly reports of RCRA groundwater monitoring data (e.g., DOE-RL 1994). A water table map for June 1993 is presented in Figure 4.1-13, Section 4.1.

4.10.5.2 Rate of Flow. The horizontal groundwater gradient in the unconfined aquifer under the LERF is approximately 0.001 between wells 299-E26-11 and 299-E26-9. An estimation of the average linear groundwater velocity can be calculated from the following equation based on Darcy's law:

$$v = \frac{(Ki)}{n} \qquad (1)$$

where:

v = Velocity in m/d (ft/d)
K = Hydraulic conductivity in m/d (ft/d)
i = Hydraulic gradient (dimensionless)
n = Effective porosity (dimensionless).

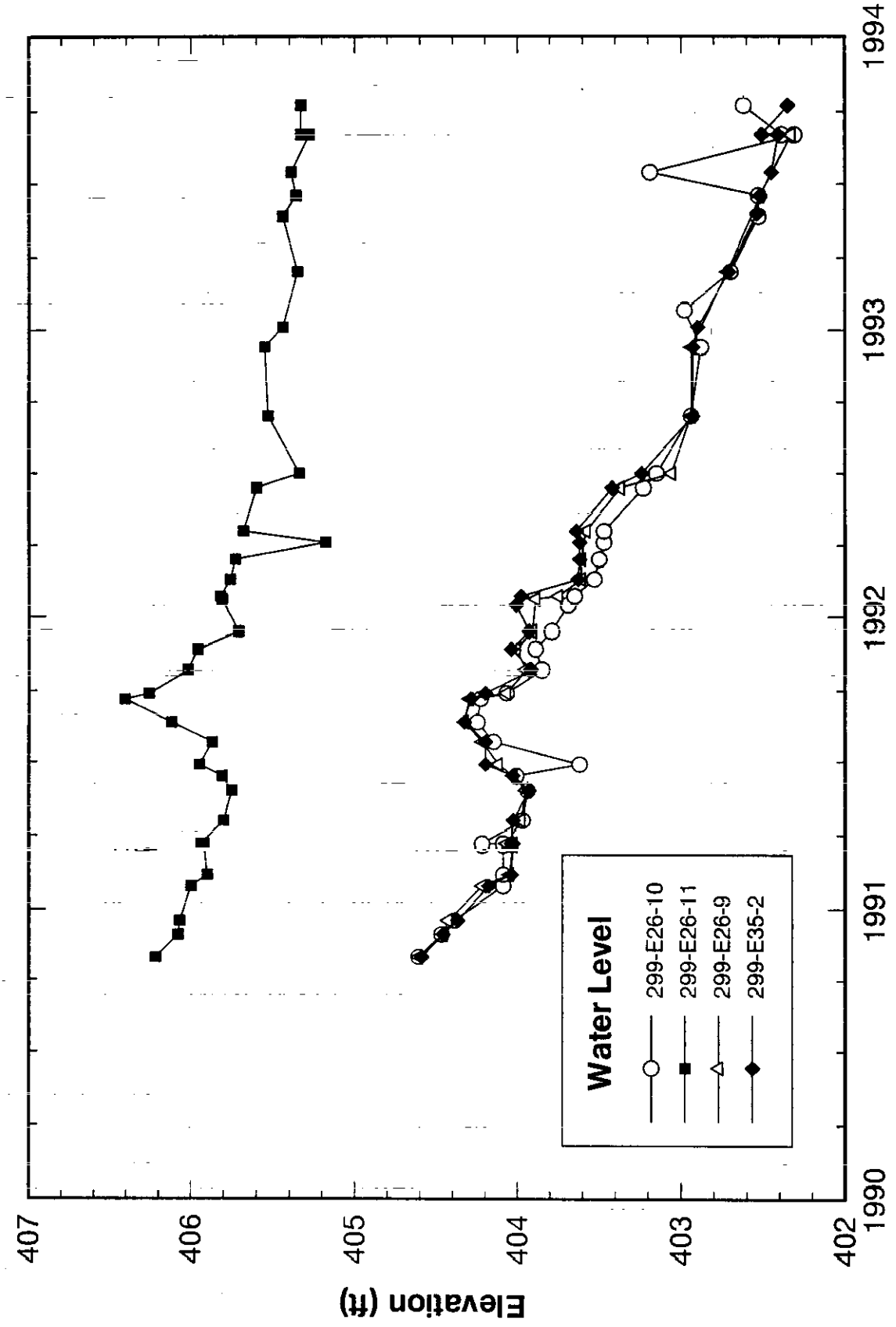
The calculations of groundwater velocity assume horizontal flow and a homogeneous aquifer. The following inputs from slug test data were used to determine the velocity near the well 299-E26-9:

K = 122 m/d (400 ft/d)
i = 0.001
n = 0.20 (Graham et al. 1981).

The given value of K is representative of the Hanford formation based on pump tests in the 200 Areas (see Figure 4.1-15, Section 4.1). The calculated velocity is 0.6 m/d (2 ft/d).

The current network is composed of four wells. The network is currently considered adequate but will be continuously evaluated as water levels and groundwater gradients change throughout time. No other wells are under consideration at this time.

Figure 4.10-4. Hydrographs of Water Level Measurements (Feet Above Sea Level) for Liquid Effluent Retention Facility Wells.



4.10.6 References

40 CFR 265, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," *Code of Federal Regulations*, as amended.

DOE-RL, 1991, *Liquid Effluent Retention Facility Dangerous Waste Permit Application*, DOE/RL-90-43, U.S. Department of Energy, Richland Field Office, Richland, Washington.

DOE-RL, 1994, *Quarterly Report of RCRA Groundwater Monitoring Data for Period July 1, 1993 through September 30, 1993*, DOE/RL-93-56-3, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

Graham, M. J., M. D. Hall, S. R. Strait, and W. R. Brown, 1981, *Hydrology of the Separations Area*, RHO-ST-42, Rockwell Hanford Operations, Richland, Washington.

WAC 173-303, "Dangerous Waste Regulations," *Washington Administrative Code*, as amended.

WHC, 1990, *Liquid Effluent Study Final Report*, WHC-EP-0367, Westinghouse Hanford Company, Richland, Washington.

WHC, 1991, *Interim Status Groundwater Monitoring Plan for the 200 East Area Liquid Effluent Retention Facility*, WHC-SD-EN-AP-024, Rev. 1, Westinghouse Hanford Company, Richland, Washington.

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4.11 2101-M POND

E. C. Thornton
Westinghouse Hanford Company

M. A. Chamness
Pacific Northwest Laboratory

4.11.1 Facility Overview

The 2101-M Pond is a U-shaped, unlined trench located west-southwest of the 2101-M Building in the southwest portion of the 200 East Area (Figure 4.11-1). It has received wastewater from the 2101-M Building heating and air conditioning system since 1953. Copper has been detected in pond soil samples and is thought to be related to piping in the 2101-M Building heating, ventilating, and air conditioning system. In 1981, Basalt Waste Isolation Project laboratories were plumbed into the discharge line from the 2101-M Building to the 2101-M Pond. From 1981 until mid-1985, these laboratories may have discharged dangerous waste into the 2101-M Pond. The most important chemicals used in the 2101-M Laboratory were barium chloride and hydrochloric and nitric acids, and they are assumed to have been disposed of in laboratory drains connected to the 2101-M Pond. Selenium and chromium are also potential contaminants associated with laboratory operations. A revision of the closure plan (DOE-RL 1993) has been written and submitted to the Washington State Department of Ecology (Ecology) for review.

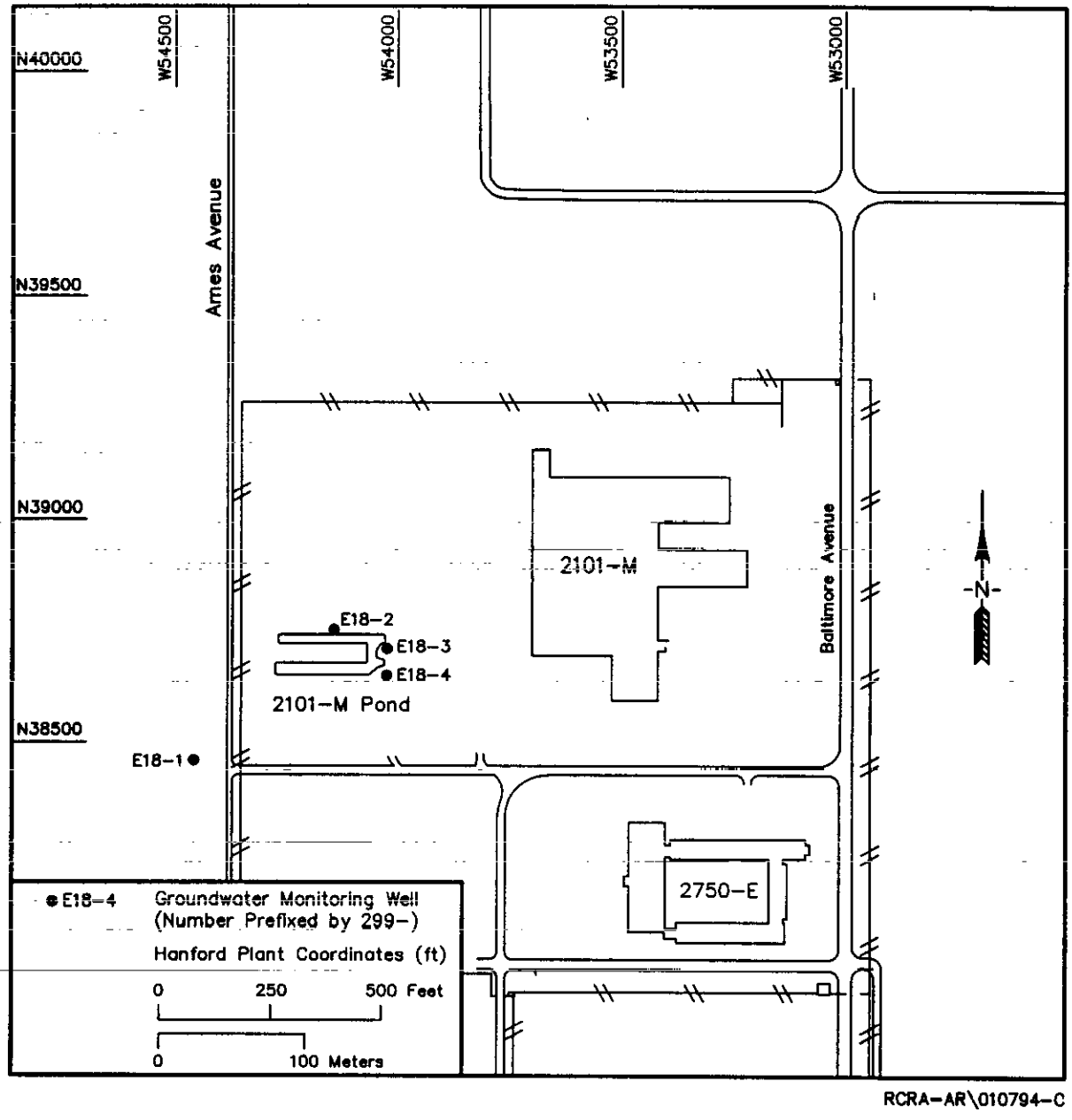
The 2101-M Pond has been monitored under *Resource Conservation and Recovery Act of 1976* (RCRA) interim-status regulations (40 *Code of Federal Regulations* [CFR] 265) in an indicator evaluation program using a four-well network since November 1989 (Chamness et al. 1989). The monitoring wells are installed in the unconfined aquifer within fluvial sand and gravel-dominated facies of the Ringold Formation (see Section 4.1). The Ringold Formation at this site is a muddy, sandy gravel to a slightly muddy gravelly sand over the screened interval, which ranges from approximately 92 to 101 m (302 to 331 ft) below top of casing. The 2101-M Pond is located within the 200-SS-1 operable unit.

4.11.2 Summary of 1993 RCRA Activities

The four wells in the monitoring network were sampled in December 1992 and June 1993 for contamination indicator, groundwater quality, and drinking water quality parameters, as well as uranium, tritium, gamma scan, and technetium. Results of these sampling event analyses are discussed in Section 4.11.4. More detailed discussions of this site were included in each of the four quarterly reports (Chamness 1993a, 1993b, 1993c; Thornton 1994).

Monthly water level measurements of the four-well monitoring network were made from October 1992 through September 1993, in addition to routine water level measurements made at the time of sampling. A discussion of the water level measurements is included in Section 4.11.5.

Figure 4.11-1. Monitoring Well Locations for the 2101-M Pond.



4.11.3 Sampling and Analysis Program

The indicator evaluation groundwater monitoring program for the 2101-M Pond is described in Chamness et al. (1989). There were no modifications to the program in 1993.

The monitoring network consists of one upgradient (299-E18-1) and three downgradient (299-E18-2, 299-E18-3, and 299-E18-4) groundwater monitoring wells installed in the uppermost portion of the unconfined aquifer. Sampling began in August 1988 and was conducted on a quarterly basis until August 1989 to establish background values. Semiannual indicator parameter evaluation monitoring was initiated in November 1989. A well location map is shown in Figure 4.11-1. Additional information regarding the monitoring network is provided in Table 4.11-1.

Samples were collected from all four wells in December 1992 and June 1993. All four wells were analyzed for the constituents listed in Table 4.11-2. Resampling for total organic halogen (TOX) only was performed in November 1992 due to high results associated with some of the wells sampled in June and July of 1992. The next regularly scheduled sampling of the monitoring network is December 1993.

4.11.4 Groundwater Chemistry

4.11.4.1 Constituents of Concern. All of the results received in 1993 were below the drinking water standards with the exception of some unfiltered metals and turbidity. Regulatory standards for turbidity do not apply to groundwater, which is measured at this site only as an indicator of solids content. Only filtered metals are used in measuring impact of the site on the groundwater. Unfiltered metals are analyzed for use as a comparison with the filtered metals and to evaluate well construction or other effects on groundwater sample data. Elevated unfiltered chromium, iron, manganese, zinc, and nickel concentrations are thought to have been introduced during or after well construction (e.g., metal corrosion products or clays). Well 299-E18-1, for example, exhibited a turbidity of 47.3 nephelometric turbidity units in June 1993 and elevated unfiltered metal concentrations, including aluminum. None of these metals are believed to have been discharged to the 2101-M Pond, and this well is upgradient of the pond.

A uranium value associated with the sampling of well 299-E18-2 in June 1992 was approximately double that of measurements obtained previously. The concentration of uranium associated with sampling of the well in December 1992 was consistent with earlier measurements, indicating that the June 1992 measurement was probably erroneous.

The four contamination indicator parameters, pH, conductance, total organic carbon (TOC), and TOX, are monitored for the continuing evaluation of the 2101-M Pond Facility's impact on groundwater. TOX was elevated in three of the four wells sampled during June and July 1992. Later sampling activities suggest that these were anomalous values. The elevated TOX is believed to be a result of laboratory problems based on the issuance of a nonconformance report by the laboratory specifically related to 2101-M Pond

Table 4.11-1. Monitoring Well Network for the 2101-M Pond.

Well	Aquifer	Sampling frequency	Water levels	Well standards	Other networks
299-E18-1[88]	Top of unconfined	S	M	RCRA	B Pond
299-E18-2[88]	Top of unconfined	S	M	RCRA	--
299-E18-3[88]	Top of unconfined	S	M	RCRA	--
299-E18-4[88]	Top of unconfined	S	M	RCRA	--

Notes: Shading denotes upgradient wells. Superscript following well number denotes the year of installation.
M = monthly sampling frequency.
RCRA = well is constructed to RCRA-specified standards.
S = semiannual sampling frequency.

Table 4.11-2. Constituents Analyzed at the 2101-M Pond.

Contamination indicator parameters		
pH	Total organic carbon	
Specific conductance	Total organic halogen	
Groundwater quality parameters		
Chloride	Manganese	Sodium
Iron	Phenols	Sulfate
Drinking water parameters		
2,4-D[a]	Endrin[a]	Methoxyclor[a]
2,4,5-TP	Fluoride	Nitrate
Arsenic	Gross alpha	Radium
Barium	Gross beta	Selenium
Cadmium	Lead[a]	Silver
Chromium	Lindane[a]	Silvex[a]
Coliform[a]	Mercury	Toxaphene[a]
Site-specific parameters		
Gamma scan[b]	Tritium[b]	Uranium[b]
Technetium[b]	Turbidity	

[a]Analyzed once a year.
[b]Will be analyzed for only a few times to help establish background contamination and groundwater flow direction.

and later unsatisfactory audit findings (see Appendix A). Specific conductance, pH, and TOC values have not exceeded that of the statistical background (see Section 4.11.4.2). Data discussed here have been presented in the quarterly reports (Chamness 1993a, 1993b, 1993c; Thornton 1994).

Comparison of the water chemistry of upgradient well 299-E18-1 with downgradient wells 299-E18-2, 299-E18-3, and 299-E18-4 indicates that a significant volume of water has entered the unconfined aquifer from the 2101-M Pond. Thus, a decrease of specific conductance (Figure 4.11-2), nitrate, and calcium in downgradient wells versus the upgradient well is interpreted to be a dilutional effect of water draining from the pond into the aquifer. Conversely, barium concentrations of about 55 ppb in downgradient wells versus 30 ppb in the upgradient well suggest that a minor amount of barium has been introduced into the aquifer (Figure 4.11-3). Chromium and selenium concentration values are similar in all wells.

4.11.4.2 Statistical Evaluation. Statistical evaluations of the data for 1993 at the 2101-M Pond consisted of the required comparisons between upgradient and downgradient wells to assess the facilities' impact on groundwater quality. The statistical method used to establish the background levels is presented in Appendix C. The critical means table (Table 4.11-3) lists the background average, background standard deviation, critical mean (or critical range, in the case of pH), and upgradient/downgradient comparison values for the four contamination indicator parameters. Note that the critical range for pH is outside the possible range (0-14). Thus, upgradient/downgradient comparison values for pH have been calculated using data from August 1988 to June 1992 for well 299-E18-1. The critical mean for TOX is presented in Table 4.11-3 for the purpose of completeness only. No comparison of TOX to the critical mean was made this year because of TOX analytical problems (see Section 4.11.4.1 and Appendix A). For chemistry data collected this year, none of the concentrations in the downgradient wells exceed the upgradient/downgradient comparison value.

4.11.5 Groundwater Flow

4.11.5.1 Groundwater Flow Direction. Water level measurements are taken monthly and before sampling the groundwater. These data are used to evaluate the groundwater gradient (Figure 4.11-4) and flow direction. The groundwater gradient across the 2101-M Pond monitoring network is difficult to determine precisely because it is very small (approximately 5×10^{-4}). The hydrograph for the four-well monitoring network (Figure 4.11-5) reflects not only the difficulty of acquiring accurate measurements but also the very slight difference in water level elevations between the four wells. The water table is declining throughout the 200 East Area because of decreased wastewater discharges to the ground in the 200 Areas. This has not affected the flow direction at the 2101-M Pond, however. The local water table map (see Figure 4.11-4) indicates that the general groundwater flow direction is still to the northeast or east. There are no data at present regarding vertical gradients and flow.

Figure 4.11-2. Specific Conductance Versus Time in Upgradient Well 299-E18-1 and Downgradient Wells 299-E18-2, 299-E18-3, and 299-E18-4.

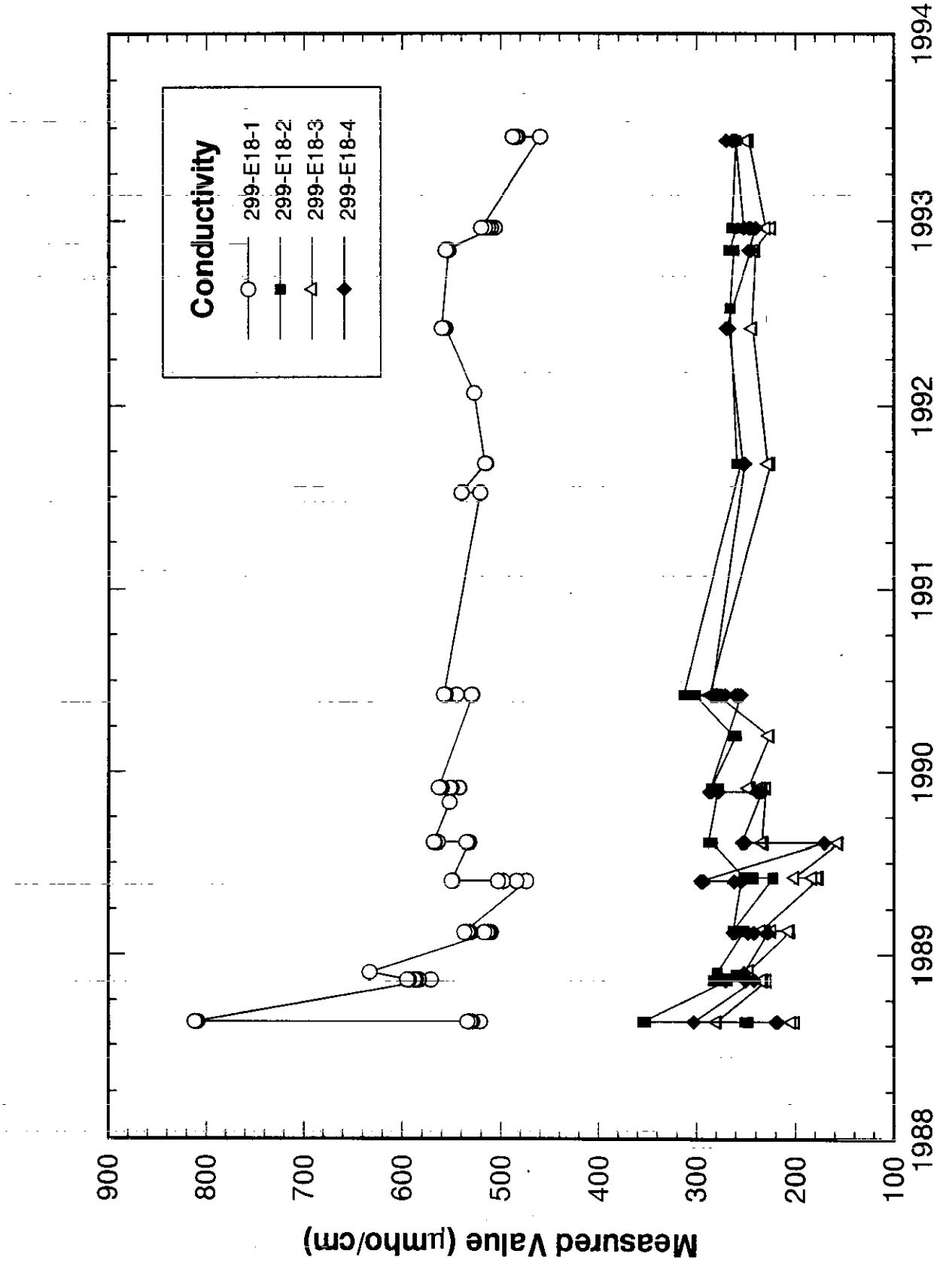


Figure 4.11-3. Unfiltered Barium Versus Time in Upgradient Well 299-E18-1 and Downgradient Wells 299-E18-2, 299-E18-3, and 299-E18-4.

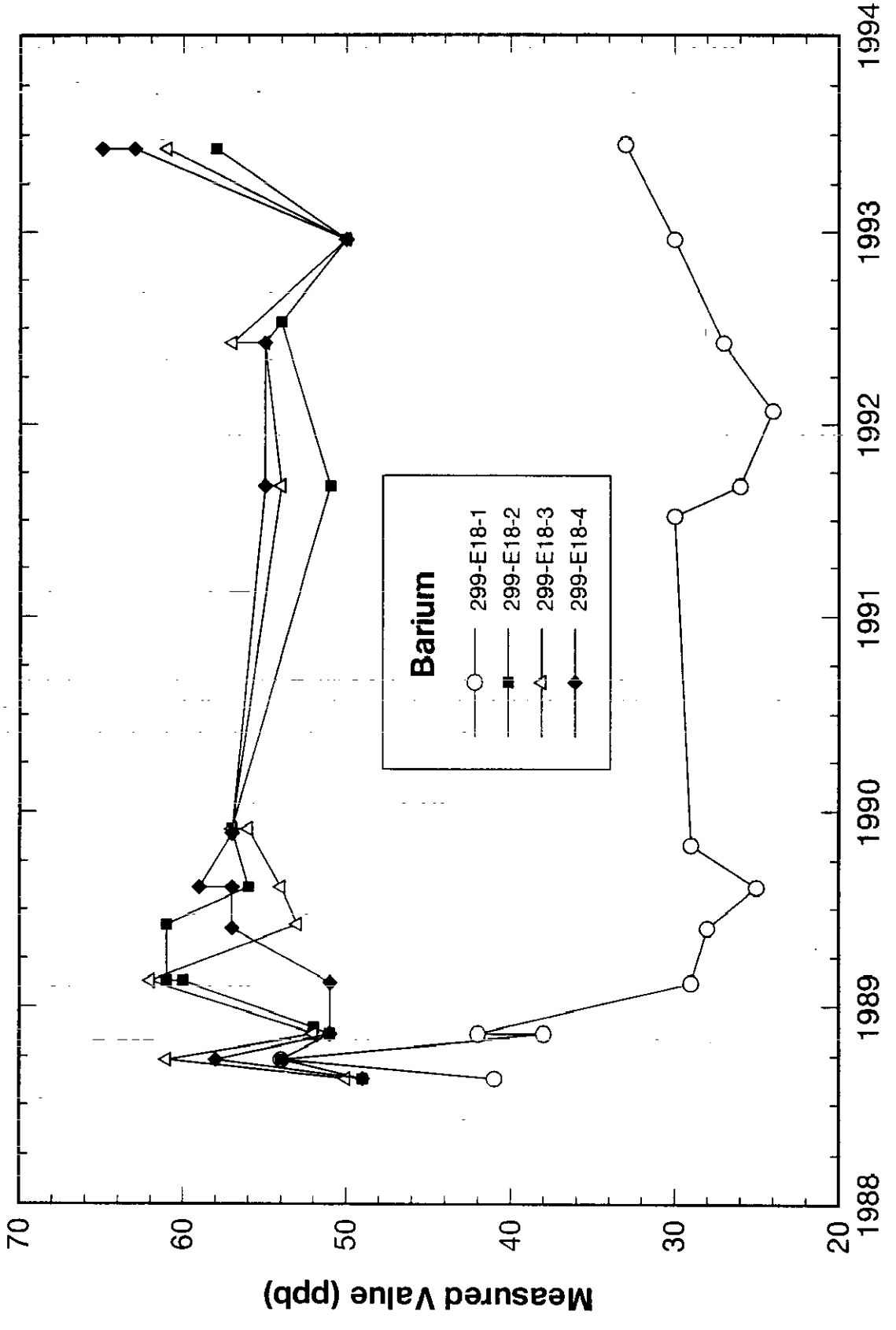


Table 4.11-3. Critical Means Table for 16 Comparisons--Background Contamination Indicator Parameter Data for the 2101-M Pond.[a,b]

Constituent (unit)	n	df	t_c	Average background	Standard deviation	Critical mean	Upgradient/ downgradient comparison value
Specific conductance (μmho/cm)	4	3	11.984	621.94	128.621	2,345.2	2,345.2
Field pH	4	3	15.145	7.804	0.656	[-3.3, 18.9]	[6.18, 9.79][e]
Total organic carbon[c] (ppb)	4	3	11.984	387.56	156.214	2,480.5	2,480.5
Total organic halogen[d] (ppb)	4	3	11.984	3.587	0.99	16.8	NC[e]

[a]Data collected from August 1988 to June 1992 for upgradient well 2-E18-1. Values calculated based on 16 comparisons.

[b]The following notations are used in this table:

df = degrees of freedom (n-1)
n = number of background replicate averages
t_c = Bonferroni critical t-value for appropriate df and 16 comparisons.

[c]Critical mean was calculated from values reported below the contractually required quantitation limits.

[d]Critical mean were calculated using data analyzed by U.S. Testing Inc., Richland, Washington.

[e]Upgradient/downgradient comparison value for pH were calculated using data from August 1988 to June 1992 (well 2-E18-1) because the critical range calculated using four quarters of data is outside the possible range for pH [0, 14].

NC = not calculated.

Water levels were measured at least once a month. These measurements show the following:

- The continued decline in water levels of approximately 0.23 m (0.75 ft) in the past year
- Gradient is still very small in the vicinity of the 2101-M Pond
- Small but consistent differences in water levels exist between the upgradient and downgradient wells.

Figure 4.11-4. 200 East Area and 2101-M Pond Water Table Map, June 1993.

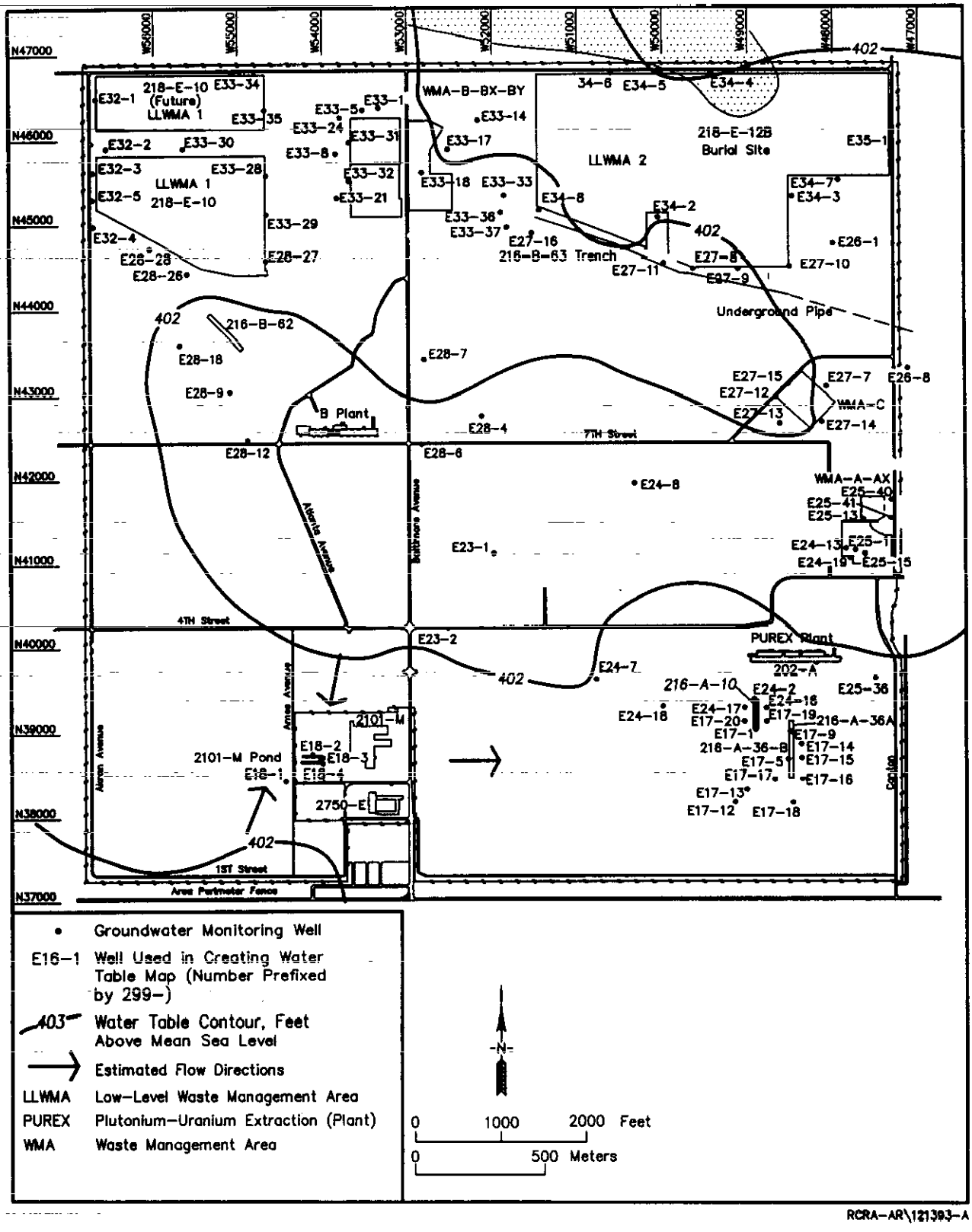
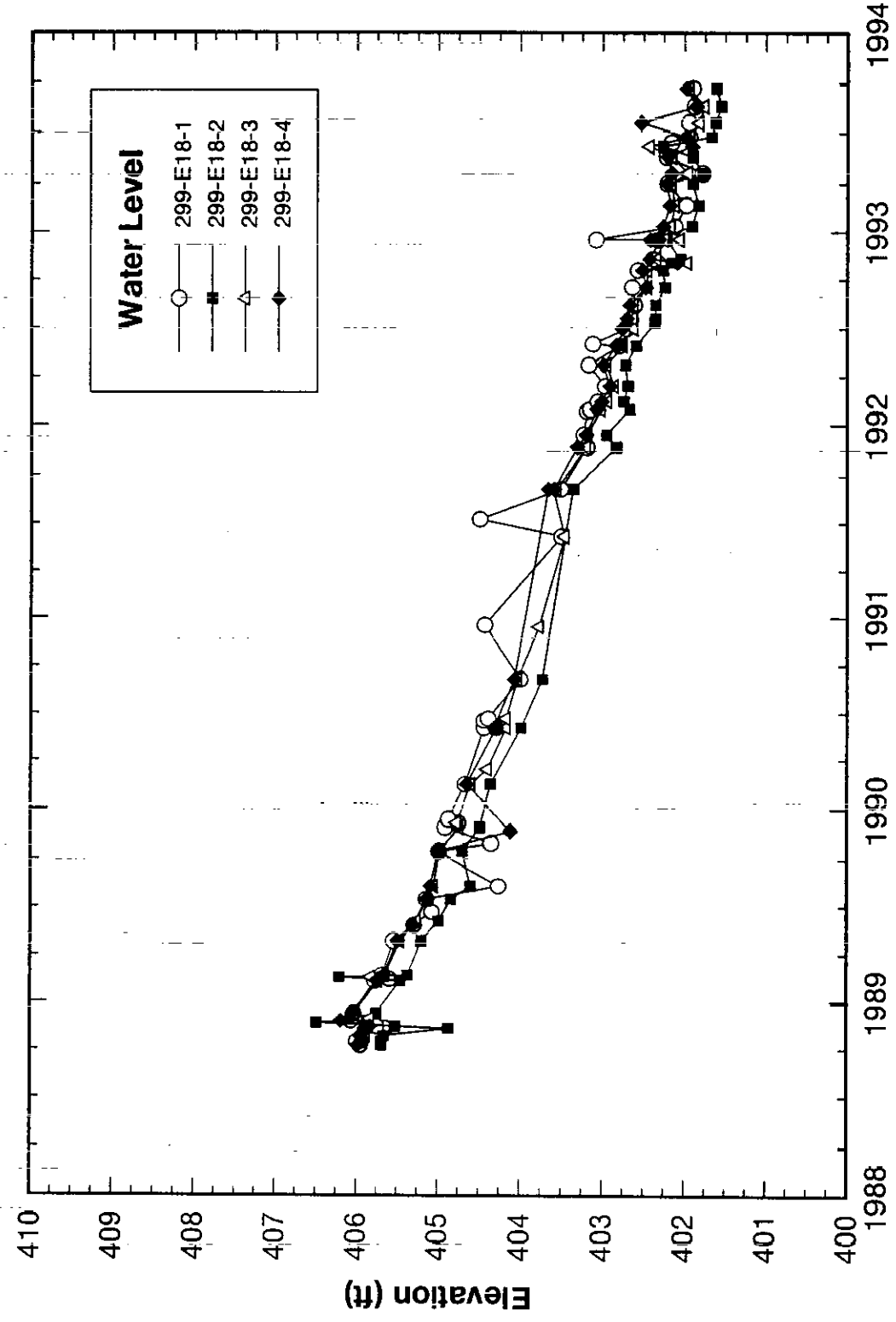


Figure 4.11-5. Hydrograph of Monthly Water Level Measurements (Feet Above Mean Sea Level) at the 2101-M Pond.

NOTE: Several anomalous data points have been removed.



4.11.5.2 Rate of Flow. An estimate of horizontal flow rates can be obtained by using Darcy's law (Freeze and Cherry 1979)

$$\bar{v} = - \frac{K}{n} \frac{\partial h}{\partial l} \qquad (1)$$

where:

$\bar{v}$ = Flow rate or average linear velocity
K = Hydraulic conductivity
n = Effective porosity
$\frac{\partial h}{\partial l}$ = Hydraulic gradient.

The monitoring wells at 2101-M Pond are completed in the Ringold Formation in a silty gravel-dominated fluvial sequence. A value of 45 m/d (150 ft/d) for hydraulic conductivity is appropriate to this unit as indicated by pumping test data (WHC 1992). If the hydraulic gradient is assumed to be 5×10^{-4} and effective porosity assumed to be 0.15, a rate of flow of 0.15 m/d (0.5 ft/d) is obtained. This should be regarded as an approximation only, however, because the hydraulic gradient is difficult to estimate at this location. At present the hydraulic gradient is very low because the water table is nearly flat.

4.11.5.3 Evaluation of Monitoring Well Network. Monitoring well locations continue to satisfy regulatory requirements based on the regional and local trend of groundwater flow near the 2101-M Pond. Small but consistent differences in water levels between the upgradient and downgradient wells indicate a northeasterly flow. Any groundwater contamination from the facility likely would be detected in the downgradient wells.

4.11.6 References

40 CFR 265, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," *Code of Federal Regulations*, as amended.

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4.12 200 AREAS LOW-LEVEL BURIAL GROUNDS

R. B. Mercer
Westinghouse Hanford Company

The 200 Areas Low-Level Burial Grounds (LLBG) consist of five Low-Level Waste Management Areas (LLWMA) (see Figure 1-1, Chapter 1.0). A Part B permit application has been submitted to the Washington State Department of Ecology (Ecology) for these facilities (DOE-RL 1989). The *Resource Conservation and Recovery Act of 1976* (RCRA) groundwater monitoring program for the LLBG began in 1988 (WHC 1989b) and is continuing under interim status.

A diverse range of both radioactive mixed and dangerous waste has been placed in the LLBG from sources including the Hanford Site and other offsite facilities. The waste includes, but is not limited to, miscellaneous dry waste, failed equipment, vehicles, contaminated soil, submarine reactor cores and reactor compartments, and cleanup waste. An inventory of the waste can be found in the *Low-Level Burial Grounds Database* (WHC 1989a). Waste has been placed in the LLBG since 1960 and is contained in unlined trenches and pits, which range from 3.7 to 18.3 m (12 to 60 ft) deep. The LLWMAs also contain some concrete caissons and retrievable storage units (RSU) that receive drummed waste. The RSUs consist of plywood- or asphalt-bottomed trenches or asphalt pads. Both trenches and pads are covered with plywood and, in some cases, an additional layer of heavy plastic and 1.2 m (4 ft) of soil. Each LLWMA will be discussed separately within this section.

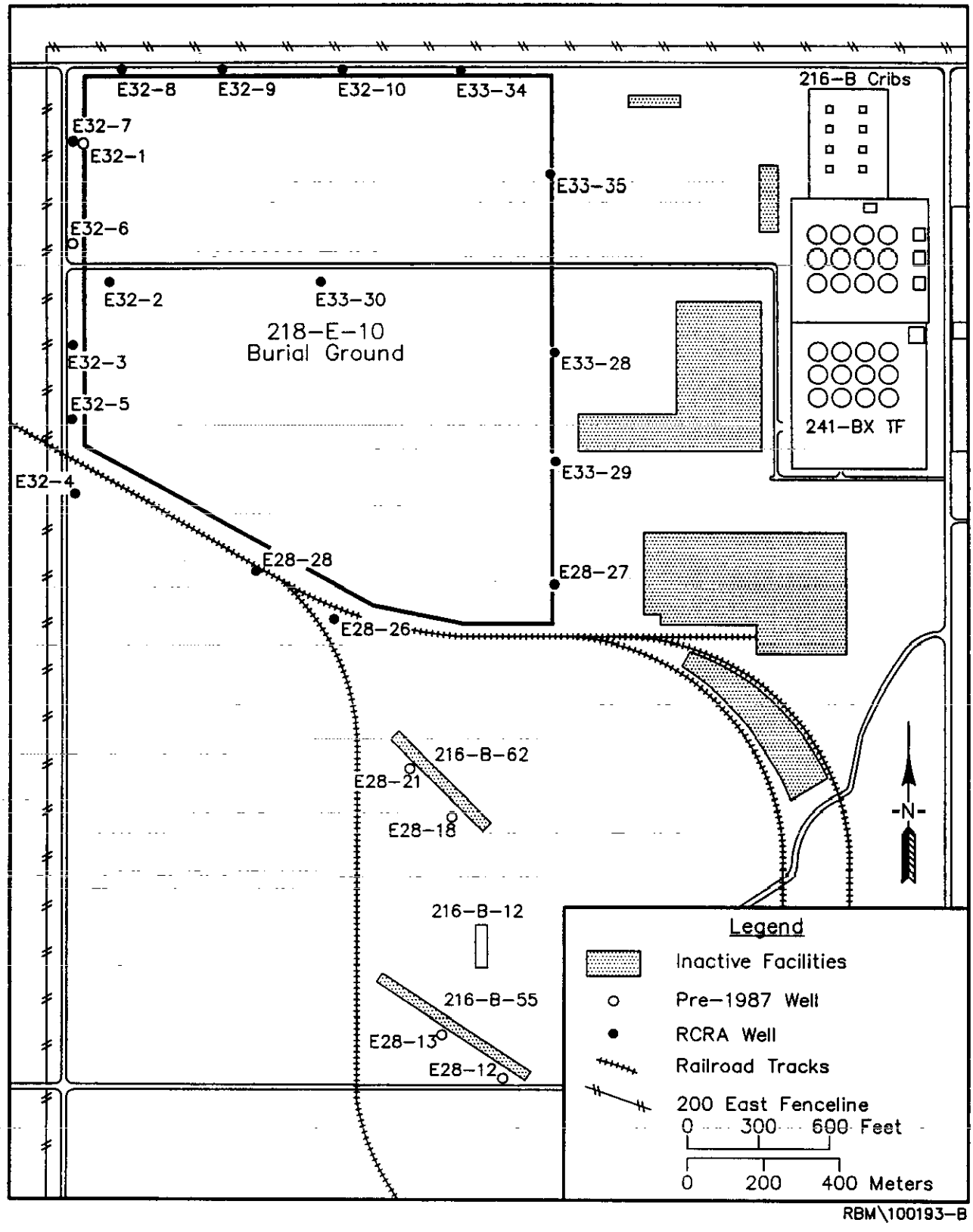
The available chemical and water level data collected at the LLBG in this reporting period are published in the 1993 quarterly reports (Mercer 1993c, 1993d, 1993e, 1994). Construction details for the 1992 drilling activities were issued this year (Mercer 1993a, 1993b). The general geology and hydrology of the 200 Areas are discussed in Section 4.1.

4.12.1 Low-Level Waste Management Area 1

4.12.1.1 LLWMA-1 Facility Overview. This LLWMA is located in the northwest corner of the 200 East Area (see Figure 1-1, Chapter 1.0). The facility is currently operating under an interim-status groundwater quality assessment plan (Chamness et al. 1990a). It includes all of the 218-E-10 Burial Ground (Figure 4.12-1). The southern portion of the burial ground is currently active, while the portion north of the road is for future expansion. The active area measures 22.9 ha (56.7 acres) and the area for future expansion measures 15.3 ha (37.7 acres), for a total area of 38.2 ha (94.4 acres).

Disposal activities at this LLWMA began in 1960 and continue to the present. Materials placed in this facility are primarily dragoff waste, failed equipment, and mixed industrial waste from the Plutonium-Uranium Extraction (PUREX) Plant, B Plant, and N Reactor. LLWMA-1 is located within the 200-BP-10 source operable unit and the 200-BP-5 groundwater operable unit.

Figure 4.12-1. Low-Level Waste Management Area 1.



4.12.1.2 LLWMA-1 Summary of 1993 RCRA Activities. This LLWMA continues to operate under the interim-status groundwater quality assessment plan (Chamness et al. 1990a) that was prepared and submitted to Ecology in January 1990. The primary focus of the assessment plan is to determine the constituent causing the high specific conductance and whether the source of the high specific conductance was LLWMA-1 or an upgradient facility. Groundwater samples were collected quarterly in 1993. Water levels were measured monthly.

4.12.1.3 LLWMA-1 Sampling and Analysis Program. The existing RCRA groundwater monitoring network consists of 16 wells (see Figure 4.12-1). Table 4.12-1 lists the wells in the LLWMA-1 monitoring network. The sampling and analysis program at LLWMA-1 was initiated in 1988. After four quarters of data had been collected, statistics were calculated to determine the critical means of the indicator parameters. Samples collected in the last quarter of 1989 indicated that specific conductance in well 299-E28-26 exceeded the established critical mean for LLWMA-1 (492.78 μmho/cm). An interim-status groundwater quality assessment monitoring program was initiated in January 1990 (Chamness et al. 1990a). Under this program sampling is on a quarterly basis until a groundwater quality assessment report is completed. A list of analytical constituents for LLWMA-1 is presented in Table 4.12-2.

4.12.1.4 LLWMA-1 Groundwater Chemistry.

4.12.1.4.1 Concentration Histories of Waste Indicators. Groundwater chemistry data for LLWMA-1 have been collected since 1988. Specific conductance data show a slight increase in the downgradient monitoring wells and a general decrease in the upgradient wells. The available data indicate that the values for specific conductance for well 299-E28-26 have fallen below the critical mean; however, the critical mean continued to be exceeded in wells 299-E32-5 and 299-E32-3 in 1993. The values for well 299-E32-2, while still well below the critical mean, have increased approximately 10% in the last year. However this upward trend appears to be flattening.

The interpretation of the data indicates that the elevated specific conductance is most likely the result of a nitrate plume beneath LLWMA-1 with an origin to the south, possibly from the 216-B-62 Crib (see Figure 4.12-1). The maximum values for specific conductance may have not yet reached the downgradient monitoring wells.

4.12.1.4.2 Distribution of Waste Constituents. Although there does not appear to be any contribution from LLWMA-1, contaminant plumes are affecting the groundwater quality beneath LLWMA-1 (see Section 4.1; Johnson 1993; WHC 1992a). Nitrate and tritium plumes are evident and appear to be the major contaminants in the area of LLWMA-1. Nitrate exceeded the drinking water standard (DWS) of 45,000 ppb in wells 299-E32-3, 299-E32-5, and 299-E33-34 at the beginning of this reporting period. The values fell below the standard by the second quarter of 1993 and are continuing the downward trend.

Tritium values indicate the presence of a plume beneath LLWMA-1 with a source to the southeast. The data suggest that the maximum concentrations have already passed beneath LLWMA-1 and that values will continue to decline with time.

Table 4.12-1. Low-Level Waste Management Area 1 Monitoring Network.

Well	Aquifer	Sampling frequency	Water levels	Well standards	Other networks
299-E28-26[87]	Top of unconfined	Q	M	RCRA	--
299-E28-27[87]	Top of unconfined	Q	M	RCRA	--
299-E28-28[90]	Top of unconfined	Q	M	RCRA	--
299-E32-2[87]	Top of unconfined	Q	M	RCRA	200-BP-1
299-E32-3[87]	Top of unconfined	Q	M	RCRA	--
299-E32-4[87]	Top of unconfined	Q	M	RCRA	B Pond
299-E32-5[89]	Top of unconfined	Q	M	RCRA	--
299-E32-6[91]	Top of unconfined	Q	M	RCRA	--
299-E32-7[91]	Top of unconfined	Q	M	RCRA	--
299-E32-8[91]	Top of unconfined	Q	M	RCRA	--
299-E32-9[91]	Top of unconfined	Q	M	RCRA	--
299-E32-10[92]	Top of unconfined	Q	M	RCRA	--
299-E33-28[87]	Top of unconfined	Q	M	RCRA	200-BP-1
299-E33-29[87]	Top of unconfined	Q	M	RCRA	200-BP-1
299-E33-30[87]	Top of unconfined	Q	M	RCRA	200-BP-1
299-E33-34[90]	Top of unconfined	Q	M	RCRA	200-BP-1
299-E33-35[90]	Top of unconfined	Q	M	RCRA	200-BP-1

Notes: Shading denotes upgradient wells. Superscript following well number denotes the year of installation.
M = frequency on a monthly basis.
Q = frequency on a quarterly basis.
RCRA = well is in compliance with RCRA standards.

Values for gross alpha from wells 299-E28-28 and 299-E32-5 have exceeded the DWS. Upgradient well 299-E28-26 is also somewhat elevated but a definite trend cannot be established. The downgradient wells generally have upward trends at this LLWMA. The results, while above the established standard, have not exceeded the historical maximum for upgradient well 299-E28-26. All values are expected to decline as the plume passes under the burial ground.

Wells 299-E33-34 and 299-E33-35 continue to have elevated levels for gross beta contamination and the trends appear to be slightly upward.

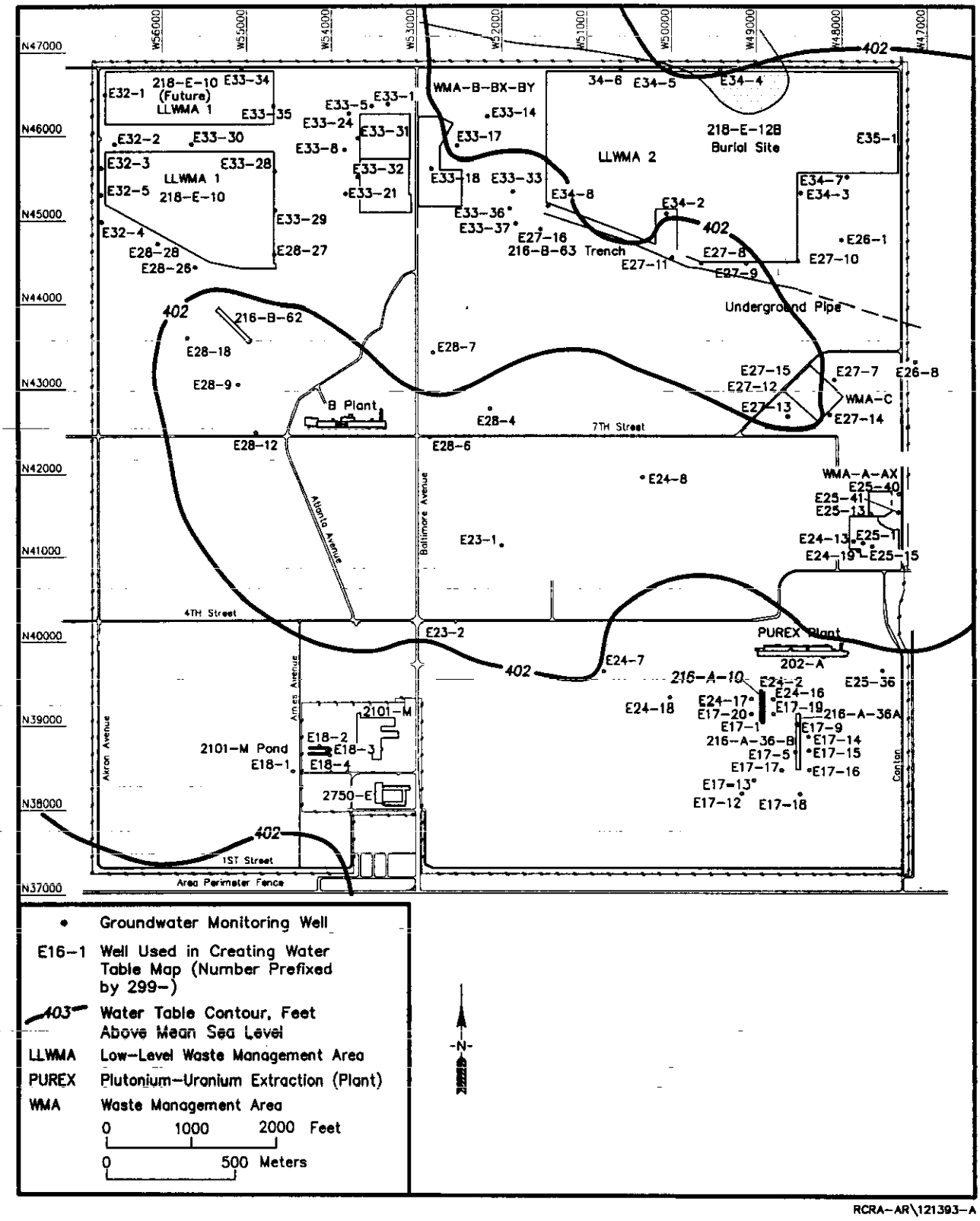
Table 4.12-2. Constituents Analyzed at the Low-Level Burial Ground.

Contamination indicator parameters		
pH	Total organic carbon	
Specific conductance	Total organic halogen	
Groundwater quality parameters		
Chloride	Manganese	Sodium
Iron	Phenols	Sulfate
Drinking water parameters		
2,4-D	Endrin	Methoxychlor
2,4,5-TP Silvex	Fluoride	Nitrate
Arsenic	Gross alpha	Radium
Barium	Gross beta	Selenium
Cadmium	Lead	Silver
Chromium	Lindane	Toxaphene
Coliform bacteria	Mercury	
Site-specific parameters for the Low-Level Burial Grounds		
1,1,2,2-tetrachloroethane	Carbon tetrachloride	Tetrachloroethylene
1,2 dichloroethane	Chlorobenzene	Toluene
1,2 dichloropropane	cis-1,1 dichloroethylene	trans-1,1 dichloroethylene
Acetonitrile	Copper	Trichloroethylene
Benzene	Cyanide	Uranium
Beryllium	Ethylbenzene	Vinyl chloride
Bromoform	Naphthalene	Xylene

4.12.1.5 LLWMA-1 Groundwater Flow.

4.12.1.5.1 Groundwater Flow Direction. The groundwater flow direction in the area of LLWMA-1 is difficult to determine using only water level data from the monitoring wells around the burial ground. The groundwater gradient in this area is extremely low and several uncertainties contribute to the difficulties in producing a water table map for this area. These uncertainties include inaccuracies in the borehole surveys, slight deviations from the vertical in the boreholes, and errors associated with the water level measurements themselves. To demonstrate the groundwater flow directions under LLWMA-1, a general map of the entire 200 East Area is presented in Figure 4.12-2. This map represents the best estimate of the water table elevation beneath LLWMA-1 in June 1993 and was generated using data not only from wells in the 200 East Area but also the surrounding areas.

Figure 4.12-2. Water Table Contour Map for the 200 East Area, June 1993.



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An interpretation of the groundwater map indicates that the general groundwater flow direction is to the northwest beneath LLWMA-1, but the low gradient makes precise determinations difficult. The groundwater flow direction will continue to be monitored and any change in status will be documented in the final groundwater quality assessment report.

4.12.1.5.2 Rate of Flow. Using the Darcy equation (equation 1) and some conservative values for hydrologic properties, an estimate of the groundwater flow velocity was determined. The hydraulic conductivity of the aquifer beneath LLWMA-1 has been estimated to be between 73 and 762 m/d (240 and 2,500 ft/d) (Last et al. 1989, page 6.8) and the effective porosity is assumed to be on the order of 0.1. Using Figure 4.12-2, an approximation of the hydraulic gradient can be determined to be 0.000125. Calculations using these values result in groundwater velocities between 0.09 and 0.95 m/d (0.3 and 3.1 ft/d). These values are highly subjective; however, they represent the best estimate of the actual conditions beneath LLWMA-1. These velocities are approximately one-third less than the 1992 estimates. This can be attributed to the lower hydraulic gradient because of the lowering of the B Pond groundwater mound and the overall decline in discharges to the ground.

$$v = \frac{Ki}{n} \qquad (1)$$

where:

v = Average linear groundwater velocity (m/d)
K = Hydraulic conductivity (m/d)
i = Hydraulic gradient
n = Effective porosity.

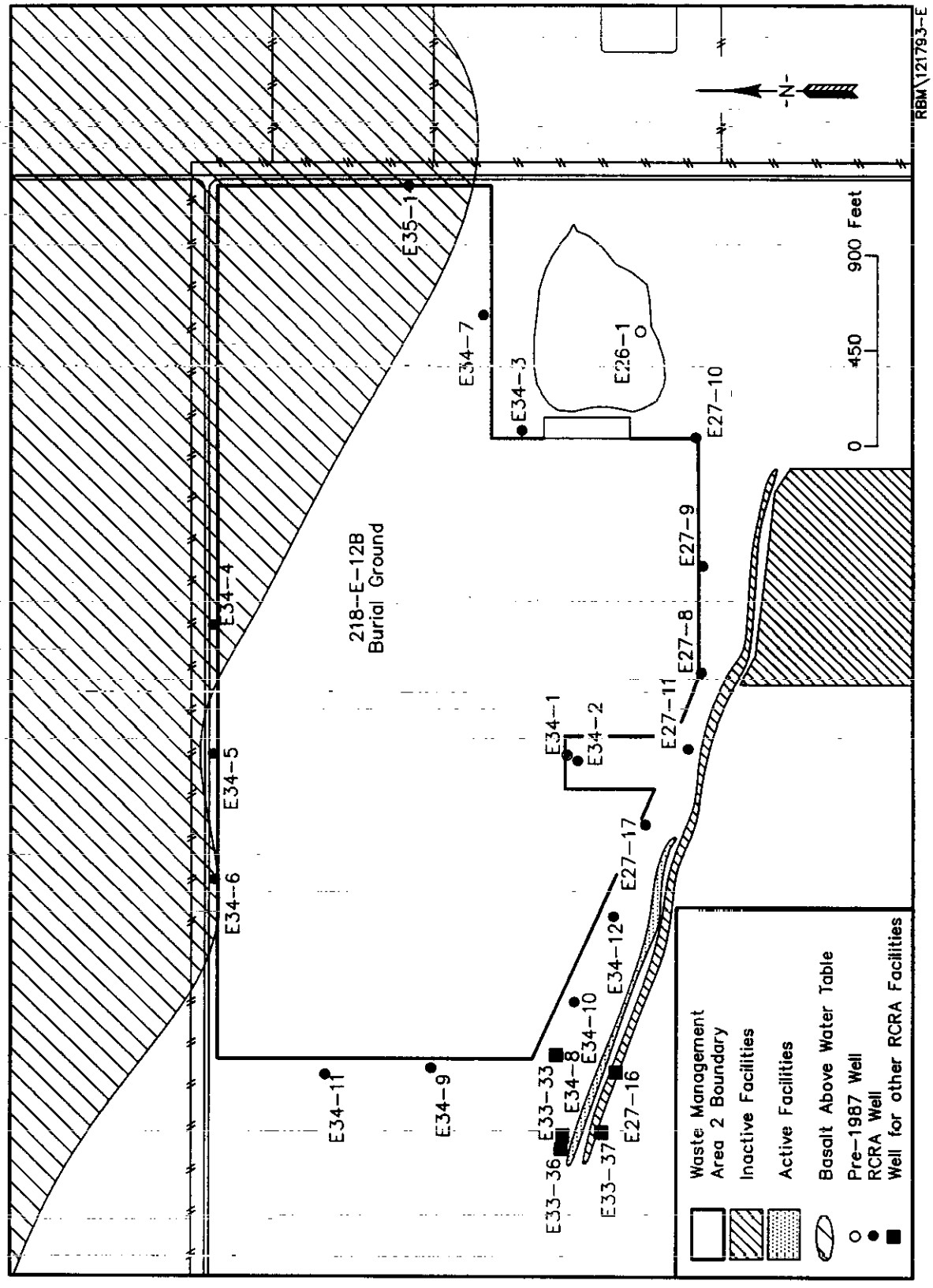
4.12.1.5.3 Evaluation of Monitoring Network. The groundwater monitoring network continues to meet requirements. There are no plans for additional groundwater monitoring wells at this time.

4.12.2 Low-Level Waste Management Area 2

4.12.2.1 LLWMA-2 Facility Overview. Currently in indicator evaluation monitoring status, LLWMA-2 is located in the northeast corner of the 200 East Area and includes all of burial ground 218-E-12B (Figures 1-1 and 4.12-3). This burial ground has a total area of 70.1 ha (173.1 acres) and has been in use since 1968. The majority of the waste deposited in this area is located in the eastern half of the burial ground. This waste consists primarily of miscellaneous dry waste and submarine reactor compartments. Parts of two trenches contain transuranic waste. LLWMA-2 is located in the 200-BP-11 source operable unit and the 200-BP-5 groundwater operable unit.

4.12.2.2 LLWMA-2 Summary of 1993 Activities. The indicator evaluation monitoring program for LLWMA-2 continued in 1993. Groundwater samples were collected semiannually in 1993. Water level measurements were made quarterly. Quarterly sampling (for four quarters) was conducted at wells 299-E34-11 and 299-E34-12 to establish baseline values.

Figure 4.12-3. Low-Level Waste Management Area 2.



4.12.2.3 LLWMA-2 Sampling and Analysis Program. The current monitoring network consists of 16 wells. Monitoring wells for LLWMA-2 are listed in Table 4.12-3 and are shown in Figure 4.12-3. The sampling and analysis program for LLWMA-2 was initiated in 1988 (WHC 1989b), with quarterly sampling until the last quarter of 1989. At that time the required statistics were calculated. No analyses from downgradient wells exceeded the critical means. Sampling was placed on a semiannual schedule. The constituent list for LLWMA-2 is the same as Table 4.12-2 with the addition of polychlorinated biphenyls.

4.12.2.4 LLWMA-2 Groundwater Chemistry Evaluation.

4.12.2.4.1 Constituents of Concern. The analysis of indicator parameters was hampered in 1993 by inconsistent results for total organic halogen (TOX). A discussion of this problem can be found in Appendix A. The analysis of the remaining three parameters indicated that the established critical means were not exceeded in any wells in 1993.

Chemical analyses indicated that unfiltered iron and chromium were above regulatory standards in 1993 in several wells. This is an ongoing problem in many RCRA wells on the Hanford Site and is thought to be a result of the drilling and well installation process. There is no evidence of contamination from LLWMA-2.

Turbidity in samples from several wells exceeded the 1 nephelometric turbidity unit (NTU) limit. There is no consistent pattern to these high values.

4.12.2.4.2 Statistical Evaluation. Statistical evaluations of data for the past year at the LLWMA-2 consisted of comparisons between upgradient and downgradient wells for any indication of contamination in the groundwater underlying the facility. Background data replicate averages, and background summary statistics are presented in Appendix D of the 1992 RCRA Annual Report (DOE-RL 1993). Statistical analyses required by 40 *Code of Federal Regulations* (CFR) 265.93(b) and *Washington Administrative Code* (WAC) 173-303-400 were performed on the samples collected from September 1988 to July 1989 for upgradient wells. Results are presented in Table 4.12-4. This table lists the background average, background standard deviation, and critical mean (or critical range, in the case of pH) for the four contamination indicator parameters from the upgradient wells. The upgradient/downgradient comparison value (or range) is the value to which current and future averages of quadruplicate measurements are compared.

If the average concentration for a parameter from a downgradient well exceeds the upgradient/downgradient comparison value listed in Table 4.12-4, that parameter is considered statistically different from background. If this is confirmed by subsequent verification sampling and analysis, the regulatory program is triggered into assessment. TOX was not evaluated because of problems associated with data quality. There were no exceedances in 1993.

Table 4.12-3. Low-Level Waste Management Area 2 Monitoring Network.

Well	Aquifer	Sampling frequency	Water levels	Well standards	Other networks
299-E27-8[87]	Top of unconfined	SA	Q	RCRA	B-63 Trench
299-E27-9[87]	Top of unconfined	SA	Q	RCRA	B-63 Trench
299-E27-10[90]	Top of unconfined	SA	Q	RCRA	--
299-E27-11[89]	Top of unconfined	SA	Q	RCRA	B-63 Trench
299-E27-17[91]	Top of unconfined	SA	Q	RCRA	B-63 Trench
299-E34-2[87]	Top of unconfined	SA	Q	RCRA	200-BP-1
299-E34-3[87]	Top of unconfined	SA	Q	RCRA	--
299-E34-4[87]	Top of unconfined	--	Dry	RCRA	--
299-E34-5[87]	Top of unconfined	SA	Q	RCRA	200-BP-1
299-E34-6[87]	Top of unconfined	--	Dry	RCRA	--
299-E34-7[89]	Top of unconfined	SA	Q	RCRA	--
299-E34-9[91]	Top of unconfined	SA	Q	RCRA	--
299-E34-10[91]	Top of unconfined	SA	Q	RCRA	B-63 Trench
299-E34-11[92]	Top of unconfined	Q	Q	RCRA	--
299-E34-12[92]	Top of unconfined	Q	Q	RCRA	--
299-E35-1[89]	Top of unconfined	--	Dry	RCRA	--

Notes: Shading denotes upgradient wells. Superscript following well number denotes the year of installation.
Q = frequency on a quarterly basis.
RCRA = well is in compliance with RCRA standards.
SA = frequency on a semiannual basis.

4.12.2.5 LLWMA-2 Groundwater Flow.

4.12.2.5.1 Groundwater Flow Direction. Water level data from LLWMA-2 monitoring wells do not present a clear picture of groundwater flow. To obtain a better overall idea of the groundwater flow regime a water table map of the 200 East Area and surroundings for June 1993 was generated (see Figure 4.12-2). The groundwater flow direction in this area is primarily from east to west. Groundwater flow is affected by the basalt high located north and east of LLWMA-2 and the presence of a groundwater mound associated with B Pond.

Table 4.12-4. Critical Means Table for 52 Comparisons--Background Contamination Indicator Parameter Data for the Low-Level Waste Management Area 2.[a,b]

Constituent (unit)	n	df	t_c	Average background	Standard deviation	Critical mean	Upgradient/ downgradient comparison value
Specific conductance (μmho/cm)	12	11	5.0293	385.875	116.987	998.3	998.3
Field pH	12	11	5.4790	8.077	0.174	[7.08, 9.07]	[7.08, 9.07]
Total organic carbon[c] (ppb)	12	11	5.0293	445.833	94.648	941.3	941.3
Total organic halogen[d] (ppb)	12	11	5.0293	4.833	2.861	9.8	NC[e]

[a]Data collected from September 1988 to July 1989 for upgradient wells 2-E27-10 and 2-E34-5. Critical means calculated based on 52 comparisons.

[b]The following notations are used in this table:
df = degrees of freedom (n-1)
n = number of background replicate averages
t_c = Bonferroni critical t-value for appropriate df and 52 comparisons.

[c]Critical mean was calculated from values reported below the contractually required quantitation limits.

[d]Critical mean were calculated using data analyzed by U.S. Testing, Inc., Richland, Washington.

[e]Upgradient/downgradient comparison value for total organic halogen cannot be established because problems associated with data quality preclude the determination of total organic halogen limit of quantitation.

NC = not calculated.

4.12.2.5.2 Rate of Flow. The groundwater gradient beneath LLWMA-2 is very slight, i.e., on the order of 0.00025. Using this gradient, an effective porosity of 0.1, and hydraulic conductivity values in the range of 426.7 to 2,042.2 m/d (1,400 to 6,700 ft/d) (Last et al. 1989) and applying Equation 1, groundwater velocities were estimated to be between 1.1 and 5.1 m/d (3.5 and 16.8 ft/d).

4.12.2.5.3 Evaluation of Monitoring Well Network. The monitoring network continues to satisfy the requirement for at least one upgradient and three downgradient wells and is adequate to monitor the burial ground. No additional monitoring wells are planned for the LLWMA-2 monitoring network.

The declining water level in this area is forcing a reevaluation of the groundwater monitoring network. Monitoring wells 299-E34-4 and 299-E35-1 remain dry. The water level in well 299-E34-6 has declined to the point where sample collection is no longer possible. There has been some difficulty with sampling well 299-E34-7 attributed to the declining water level. Sediment appears to have accumulated in well 299-E34-7, thereby blocking the pump intake. Well maintenance has been scheduled for this well. When this situation is resolved, well 299-E34-7 may be redesignated as an upgradient well. Well 299-E34-3 will also be evaluated for this purpose.

4.12.3 Low-Level Waste Management Area 3

4.12.3.1 LLWMA-3 Facility Overview. Currently, LLWMA-3 is in assessment status as a result of elevated TOX values at well 299-W7-4. Burial grounds 218-W-3A, 218-W-3AE, and 218-W-5 comprise LLWMA-3, which is located in the north-central portion of the 200 West Area (Figures 1-1 and 4.12-4). These facilities cover an area of 74.3 ha (183.7 acres). Burial ground 218-W-3A began accepting waste in 1970 and has received primarily ion-exchange resins, and failed equipment (e.g., tanks, pumps, ovens, agitators, heaters, hoods, jumpers, vehicles, and accessories). This burial ground also contains remote-handled transuranic waste in RSUs. Burial ground 218-W-3AE was put in operation in 1981 and contains low-level and mixed waste. This includes rags, paper, rubber gloves, broken tools, and industrial waste. Burial ground 218-W-5 first received waste in 1986. This burial ground contains low-level and low-level mixed waste, including lead bricks and shielding. LLWMA-3 is in the 200-ZP-3 source operable unit and the 200-ZP-1 groundwater operable unit.

4.12.3.2 LLWMA-3 Summary of 1993 Activities. In 1993, LLWMA-3 continued to operate under the interim-status groundwater quality assessment plan (Chamness et al. 1990b) submitted to Ecology in February 1990. Groundwater samples were collected quarterly in 1993. Water level measurements were taken monthly.

Two additional monitoring wells were installed in 1993. Drilling was performed to comply with the *Hanford Federal Facility Agreement and Consent Order*, Milestone M-24-31 (Ecology et al. 1992). Construction details for the new wells will be presented in a borehole completion report. The new wells are upgradient monitoring wells and are to be completed using 10-cm (4-in.) stainless steel casing and screens. Both wells will have dedicated HydroStar[1] pumps installed for sampling. Sampling began at well 299-W10-21 in the last quarter of 1993. Sampling at well 299-W10-20 will commence as soon as possible after completion.

4.12.3.3 LLWMA-3 Sampling and Analysis Program. Twenty groundwater wells monitor LLWMA-3; six upgradient and fourteen downgradient wells. One upgradient and one downgradient well monitor the bottom of the uppermost aquifer. A complete list of groundwater monitoring wells for LLWMA-3 is presented in Table 4.12-5; the wells are shown in Figure 4.12-4. Quarterly

[1]Hydrostar is a trademark of Instrumentation Northwest Incorporated.

Figure 4.12-4. Low-Level Waste Management Area 3.

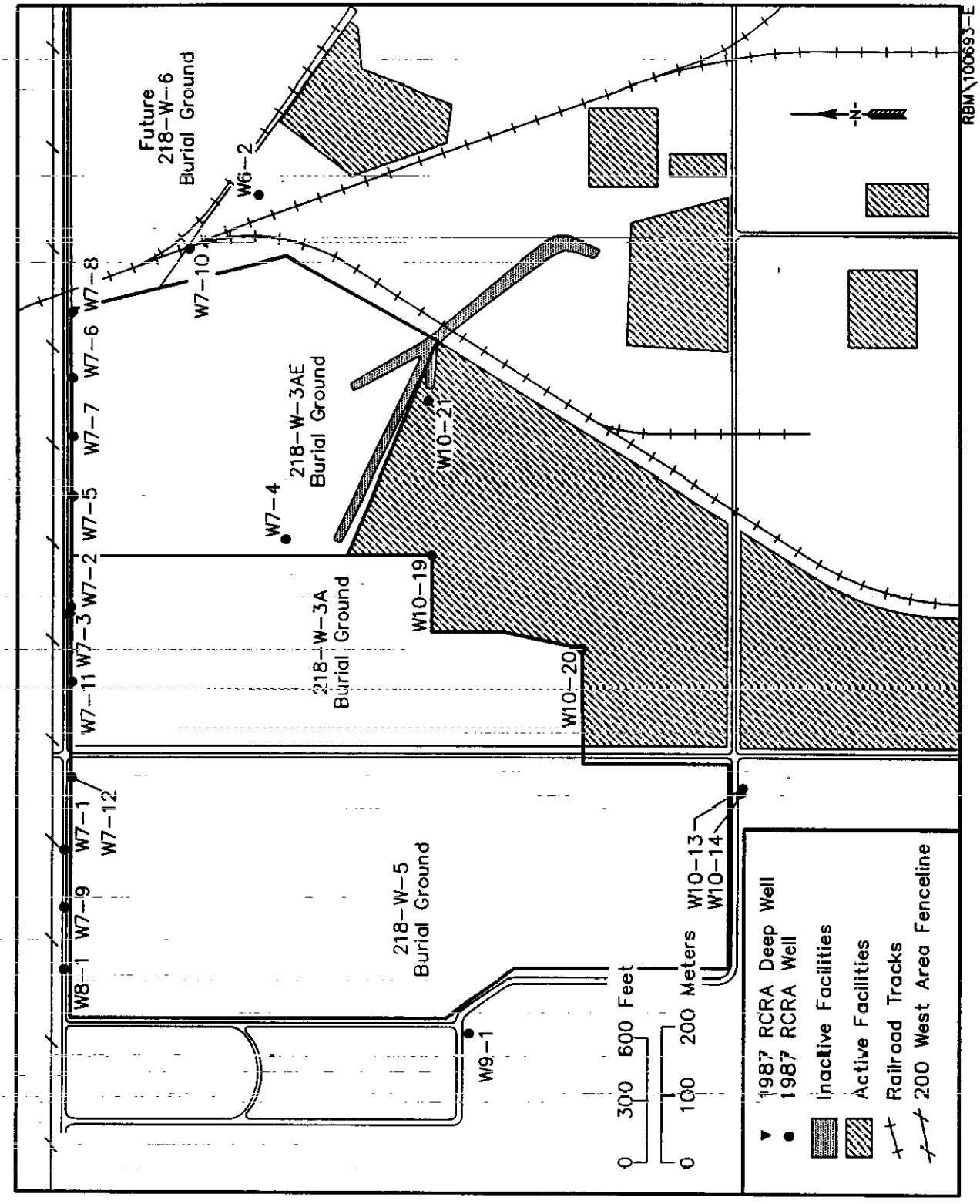


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Figure 4.12-4. Low-Level Waste Management Area 3.

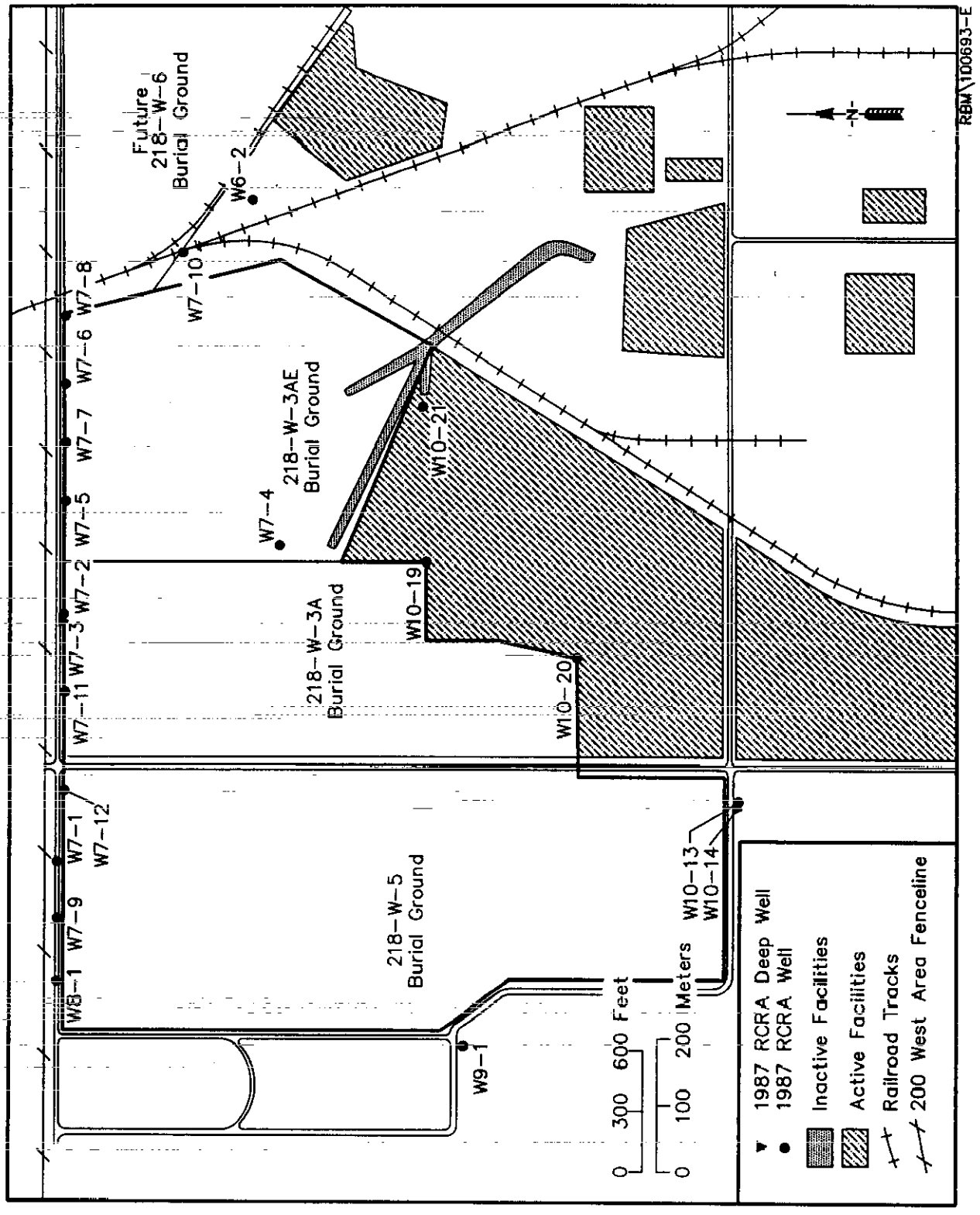


Table 4.12-5. Low-Level Waste Management Area 3 Monitoring Network.

Well	Aquifer	Sampling frequency	Water levels	Well standards	Other networks
299-W6-2[87]	Top of unconfined	Q	M	RCRA	LLWMA-5
299-W7-1[87]	Top of unconfined	Q	M	RCRA	--
299-W7-2[87]	Top of unconfined	Q	M	RCRA	--
299-W7-3[87]	Deep unconfined	Q	M	RCRA	--
299-W7-4[87]	Top of unconfined	Q	M	RCRA	--
299-W7-5[87]	Top of unconfined	Q	M	RCRA	--
299-W7-6[87]	Top of unconfined	Q	M	RCRA	--
299-W7-7[89]	Top of unconfined	Q	M	RCRA	--
299-W7-8[89]	Top of unconfined	Q	M	RCRA	--
299-W7-9[90]	Top of unconfined	Q	M	RCRA	--
299-W7-10[90]	Top of unconfined	Q	M	RCRA	LLWMA-5
299-W7-11[91]	Top of unconfined	Q	M	RCRA	--
299-W7-12[91]	Top of unconfined	Q	M	RCRA	--
299-W8-1[87]	Top of unconfined	Q	M	RCRA	--
299-W9-1[87]	Top of unconfined	Q	M	RCRA	--
299-W10-13[87]	Top of unconfined	Q	M	RCRA	--
299-W10-14[87]	Deep unconfined	Q	M	RCRA	--
299-W10-19[92]	Top of unconfined	Q	M	RCRA	--
299-W10-20[93]	Top of unconfined	Q	M	RCRA	--
299-W10-21[93]	Top of unconfined	Q	M	RCRA	--

Notes: Shading denotes upgradient wells. Superscript following well number denotes the year of installation.
M = frequency on a monthly basis.
Q = frequency on a quarterly basis.
RCRA = well is in compliance with RCRA standards.

groundwater sampling at LLWMA-3 began in 1988. Statistical analysis was conducted after four quarters of data had been collected to determine critical means for the indicator parameters at LLWMA-3. A constituent list is presented in Table 4.12-2. Samples collected in the last quarter of 1989 indicated that TOX values in downgradient well 299-W7-4 exceeded the critical mean (95.5 ppb) calculated for LLWMA-3. The interim-status groundwater quality assessment plan (Chamness et al. 1990b) prepared in response to the elevated TOX values, called for continued quarterly sampling at least through the end of 1990, with the results to be presented in the annual report. The quarterly sampling will continue until a final groundwater quality assessment report is issued.

4.12.3.4 LLWMA-3 Groundwater Chemistry.

4.12.3.4.1 Concentration Histories of Waste Indicators. The values for TOX continue to exceed the established critical mean for LLWMA-3 at well 299-W7-4. TOX in well 299-W6-2 has increased over the past year and also exceeds the critical mean of 95.5 ppb. Values for TOX from the new upgradient well 299-W10-19 are well above the values from wells 299-W6-2 and 299-W7-4. Other contamination indicator parameters are below DWSs, with the exception of pH at well 299-W7-6. The pH values at this well are above the DWS of 8.5 by a few tenths; however, there may be a slight downward trend.

4.12.3.4.2 Distribution of Waste Constituents. Carbon tetrachloride and nitrate have been consistently above DWSs at LLWMA-3. Both of these constituents are trending upward in the LLWMA-3 monitoring wells, especially in upgradient wells and the wells near burial ground 216-W-3AE. These elevated values can be attributed to contaminant plumes originating to the south of LLWMA-3. These plumes have been documented in Section 4.1; Johnson (1993); WHC (1992b). There does not appear to be any groundwater contamination directly attributable to LLWMA-3.

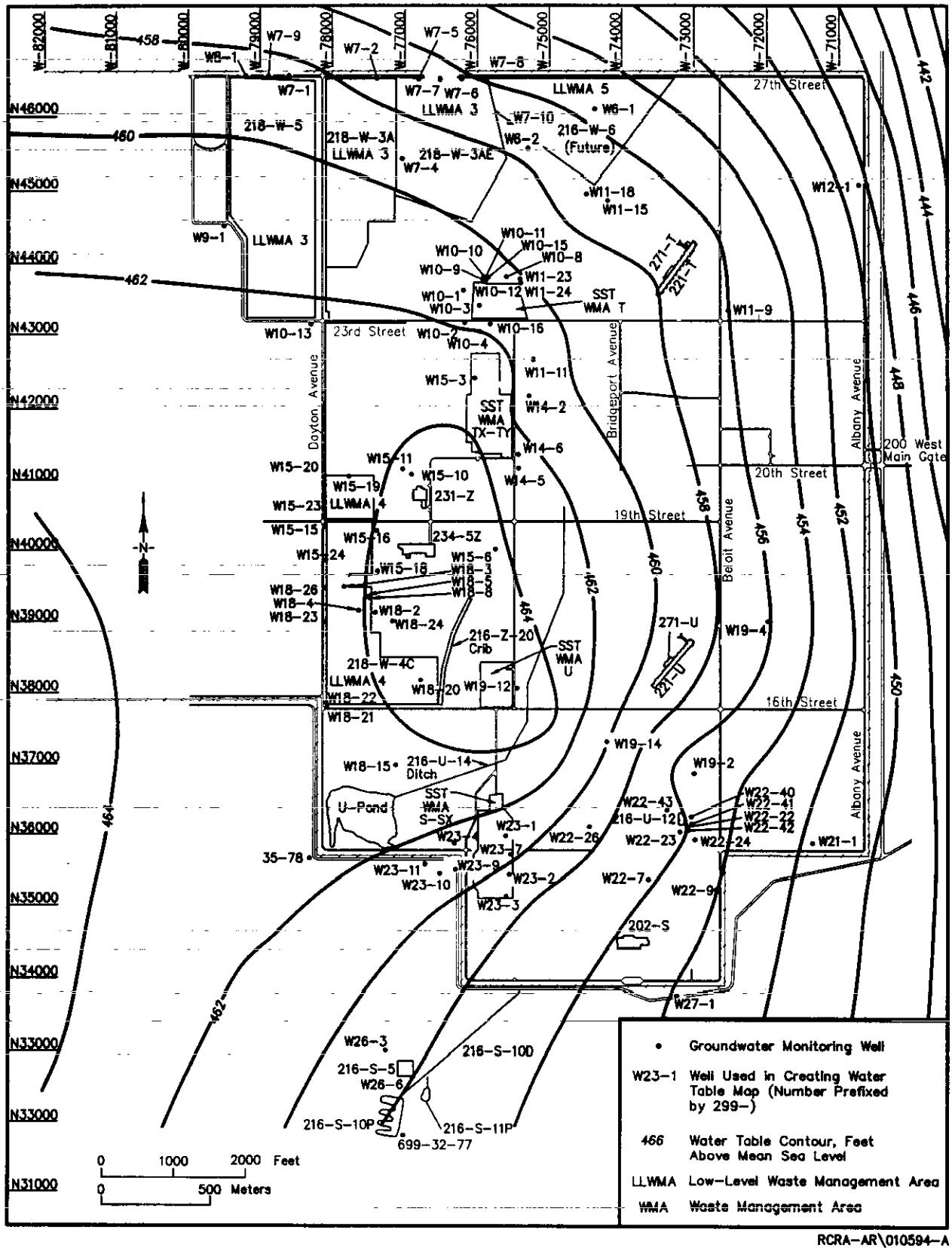
Well 299-W7-6 also has shown a slight increase in gross alpha in 1993. After a peak in 1990 the values for gross alpha had dropped below the 15-pCi/L standard.

Turbidity has been a problem in many of the LLWMA-3 monitoring wells. This is thought to be one of the major contributors to the elevated unfiltered metals (i.e., chromium, iron, and manganese).

4.12.3.5 LLWMA-3 Groundwater Flow.

4.12.3.5.1 Groundwater Flow Direction. A water table map of the entire 200 West Area (Figure 4.12-5) has been constructed in an attempt to present an overall concept of the groundwater flow pattern beneath LLWMA-3. This map used water level data from June 1993. Figure 4.12-5 generally confirms the flow directions presented previously in the groundwater monitoring plan (Last et al. 1989, page 6.20). The flow direction generally is northward with a slight eastward component, which increases to the east. The eastward component is increasing as expected, resulting from the decreased liquid disposal in this area.

Figure 4.12-5. Water Table Contour Map for the 200 West Area, June 1993.



RCRA-AR\010594-A

Water level data from the two groundwater wells that monitor the base of the unconfined aquifer indicate that the vertical groundwater flow in this area is downward. The water levels in shallow well 299-W7-2 are consistently greater than those in nearby deep well 299-W7-3 by approximately 0.3 m (1 ft). Water levels in adjacent deep shallow well 299-W10-13 are generally 0.08 m (0.25 ft) greater than in well 299-W10-14.

4.12.3.5.2 Rate of Groundwater Flow. The rate of groundwater flow beneath LLWMA-3 can be estimated using the Darcy equation (equation 1). Values of hydraulic conductivity (0.02 to 9.8 m/d [0.06 to 32 ft/d]) from Last et al. (1989, page 6.18), a conservative effective porosity of 0.1, and a hydraulic gradient of 0.0015, result in a groundwater velocity from 0.0003 to 0.15 m/d (0.0009 to 0.48 ft/d). An average hydraulic conductivity value of 1.5 m/d (5 ft/d) gives a groundwater velocity of 0.023 m/d (0.08 ft/d).

4.12.3.5.3 Evaluation of Monitoring Well Network. With the addition of the two 1993 upgradient wells, the monitoring well network for LLWMA-3 is complete. When sufficient data have been collected from the new upgradient wells the critical means for the indicator parameters will be reestablished.

4.12.4 Low-Level Waste Management Area 4

4.12.4.1 LLWMA-4 Facility Overview. Waste Management Area 4 covers 24.4 ha (60.3 acres) in the south-central portion of the 200 West Area (see Figure 1-1, Chapter 1.0) and is currently in indicator evaluation monitoring status. Burial grounds 218-W-4B and 218-W-4C make up LLWMA-4 (Figure 4.12-6). Burial ground 218-W-4B first received waste in 1968 and contains mixed and retrievable transuranic waste in trenches and 12 caissons. One caisson is believed to contain mixed waste. Waste was first deposited in burial ground 218-W-4C in 1978. Transuranic, mixed, and low-level waste has been placed in burial ground 218-W-4C. The waste includes contaminated soil, decommissioned equipment, and remote-handled transuranic waste. Several trenches in LLWMA-4 have been designed as RSUs. LLWMA-4 is within the 200-ZP-3 source operable unit and the 200-ZP-1 and 200-UP-1 groundwater operable units.

The monitoring network at LLWMA-4 has a total of 17 wells; 6 upgradient and 11 downgradient. Table 4.12-6 presents a list of all RCRA monitoring wells for LLWMA-4, and Figure 4.12-6 shows the well locations.

4.12.4.2 LLWMA-4 Summary of 1993 Activities. Indicator evaluation monitoring continued at LLWMA-4 in 1993. Groundwater chemistry samples were collected semiannually in 1993. Quarterly water level measurements were collected at all wells. Monitoring wells 299-W18-27, 299-W18-28, 299-W18-29, and 299-W18-32 were still being sampled quarterly to establish baseline conditions.

4.12.4.3 LLWMA-4 Sampling and Analysis Program. Groundwater sampling at LLWMA-4 began in 1988 (WHC 1989b) and continued on a quarterly basis until the last quarter of 1989. The required statistics were calculated and downgradient wells did not exceed the critical means established for the indicator parameters in 1993. Indicator evaluation sampling is on a semiannual basis for constituents listed in Table 4.12-2.

Figure 4.12-6. Low-Level Waste Management Area 4.

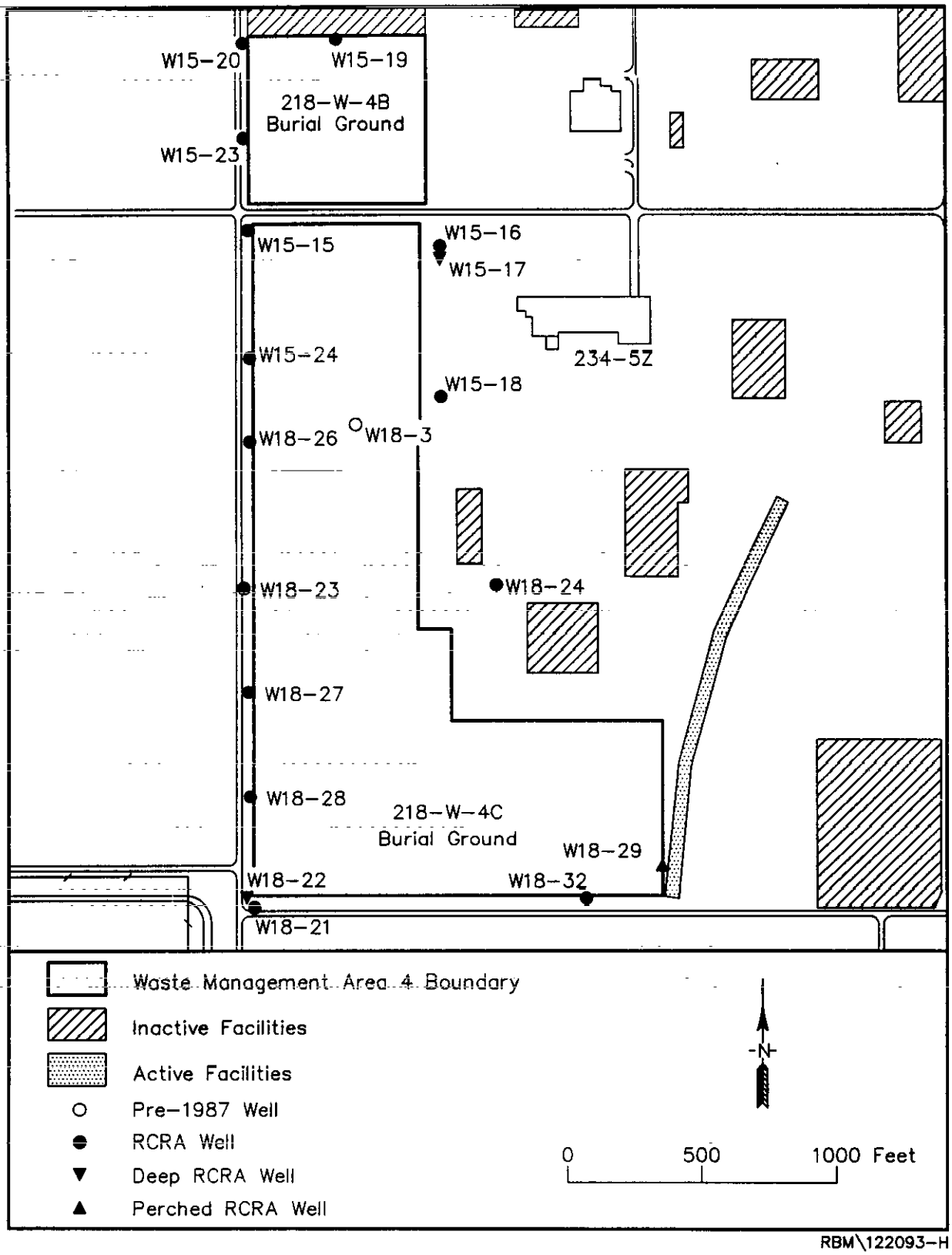


Table 4.12-6. Low-Level Waste Management Area 4 Monitoring Network.

Well	Aquifer	Sampling frequency	Water levels	Well standards	Other networks
299-W15-15[87]	Top of unconfined	SA	Q	RCRA	--
299-W15-16[87]	Top of unconfined	SA	Q	RCRA	--
299-W15-17[87]	Deep unconfined	SA	Q	RCRA	--
299-W15-18[87]	Top of unconfined	SA	Q	RCRA	--
299-W15-19[89]	Top of unconfined	SA	Q	RCRA	--
299-W15-20[89]	Top of unconfined	SA	Q	RCRA	--
299-W15-23[90]	Top of unconfined	SA	Q	RCRA	--
299-W15-24[89]	Top of unconfined	SA	Q	RCRA	--
299-W18-21[87]	Top of unconfined	SA	Q	RCRA	--
299-W18-22[87]	Deep unconfined	SA	Q	RCRA	--
299-W18-23[87]	Top of unconfined	SA	Q	RCRA	--
299-W18-24[87]	Top of unconfined	SA	Q	RCRA	--
299-W18-26[89]	Top of unconfined	SA	Q	RCRA	--
299-W18-27[91]	Top of unconfined	Q	Q	RCRA	--
299-W18-28[91]	Top of unconfined	Q	Q	RCRA	--
299-W18-29[91]	Perched zone	Q	Q	RCRA	--
299-W18-32[92]	Top of unconfined	Q	Q	RCRA	--

Notes: Shading denotes upgradient wells. Superscript following well number denotes the year of installation.
Q = frequency on a quarterly basis.
RCRA = well is in compliance with RCRA standards.
SA = frequency on a semiannual basis.

4.12.4.4 LLWMA-4 Groundwater Chemistry.

4.12.4.4.1 Constituents of Concern. It does not appear that LLWMA-4 has contributed to groundwater contamination. The samples from the downgradient wells have not exceeded the critical means established for the indicator parameters. Concentrations of CCl_4 above DWSs were found in most wells in 1993; the elevated values are thought to be related to the plumes discussed in Section 4.1; Johnson (1993); WHC (1992b). The most likely source for the CCl_4 is the 216-Z-18 Crib and other facilities associated with Z Plant located to the east of LLWMA-4.

There was a dramatic increase in tritium in wells 299-W15-15, 299-W15-16, and 299-W15-18 in the third quarter of 1993. The values exceed the DWS. There is no known tritium plume in the immediate vicinity and these values may by erroneous. This condition will be monitored to determine the validity of these results.

The TOX levels in the groundwater historically have been high beneath LLWMA-4. The high levels are related to the CCl_4 plume. The upgradient wells are generally higher than the downgradient wells. Specific conductance and pH are both below the DWSs.

Nitrate also exceeded the DWSs in wells 299-15-15, 299-15-16, 299-15-18, and 299-15-19 this year. This is most likely related to the nitrate plume described in Section 4.1; Johnson (1993); WHC (1992b).

Unfiltered metals (i.e., chromium, iron, and manganese) were reported above DWSs in many wells this year. Concentrations in the filtered samples are below the standards. These metals are constituents in steel well casing and screens, and their presence in unfiltered samples is assumed to be due to particles of well materials.

4.12.4.4.2 Statistical Evaluation. Statistical evaluations of data for the past year at the LLWMA-4 consisted of re-establishing background because of an additional upgradient well (299-W18-32) was installed in 1992, and comparisons between upgradient and downgradient wells for any indication of contamination in the groundwater underlying the facility. Statistical analyses required by 40 CFR 265.93(b) and WAC 173-303-400 were performed on the samples collected from 1988 to July 1989 for shallow upgradient wells 2-W15-16, 2-W15-18, and 2-W18-24, and 1993 samples from 200-W18-32. Data tables are presented in Appendix C. Results are presented in Table 4.12-7. This table lists the background average, background standard deviation, and critical mean (or critical range, in the case of pH) for the four contamination indicator parameters from the upgradient wells. The upgradient/downgradient comparison value (or range) is the value to which current and future averages of quadruplicate measurements are compared.

If the average for a parameter from a downgradient well exceeds the upgradient/downgradient comparison value listed in Table 4.12-6, that parameter is considered statistically different from background. If this is confirmed by subsequent verification sampling and analysis, the regulatory program is triggered into assessment. TOX was not evaluated because of problems associated with data quality. There were no exceedances in 1993.

4.12.4.5 LLWMA-4 Groundwater Flow.

4.12.4.5.1 Groundwater Flow Direction. The water table map for the 200 West Area, presented in Figure 4.12-5, indicates that the original interpretation of groundwater flow direction beneath LLWMA-4 (Last et al. 1989, page 6.20) is still valid. The flow direction is primarily to the west, trending to northwest in the northern portions of LLWMA-4, and possibly slightly to the southwest in the extreme southern portions of LLWMA-4 (see Figure 4.12-5).

Table 4.12-7. Critical Means Table for 56 Comparisons--Background Contamination Indicator Parameter Data for the Low-Level Waste Management Area 4.[a,b]

Constituent (unit)	n	df	t_c	Average background	Standard deviation	Critical mean	Upgradient/ downgradient comparison value
Specific conductance (μmho/cm)	16	15	4.586	328.594	133.345	958.9	958.9
Field pH	16	15	4.938	7.779	0.261	[6.45, 9.11]	[6.45, 9.11]
Total organic carbon (ppb)	15	14	4.676	470.0	142.428	1,157.8	1,157.8
Total organic halogen[c] (ppb)	11	10	5.2814	2,029.796	2,002.864	13,078	NC

[a]Data collected from October 1988 to July 1989 for upgradient wells 2-W15-16, 2-W15-18, and 2-W18-24 and from October 1992 to August 1993 for the newly installed upgradient well 2-W18-32. Critical means calculated based on 56 comparisons.

[b]The following notations are used in this table:
df = degrees of freedom (n-1)
n = number of background replicate averages
t_c = Bonferroni critical t-value for appropriate df and 56 comparisons.

[c]Critical mean were calculated using data analyzed by U.S. Testing, Inc., Richland, Washington.
NC = not calculated.

The vertical groundwater flow in this area is downward based on water levels from the wells that monitor the base of the unconfined aquifer (wells 299-W15-17 and 299-W18-22). The water levels in these wells are consistently lower than the nearby wells monitoring the top of the unconfined aquifer. The differences are approximately 0.08 m (0.25 ft) between wells 299-W15-16 and 299-W15-17 and 0.2 m (0.8 ft) between wells 299-W18-21 and 299-W18-22.

4.12.4.5.2 Rate of Flow. The groundwater flow velocity calculated for LLWMA-4 is in the range of 0.003 to 0.35 m/d (0.01 to 1.1 ft/d). These values were determined using an approximate hydraulic gradient of 0.0006, effective porosity of 0.1, and values of hydraulic conductivity from 0.52 to 60.96 m/d (1.7 to 200 ft/d) (Last et al. 1989, pages 6.18 and 6.19). The lower velocity value uses a hydraulic conductivity from well 299-W18-22, which monitors the

bottom of the uppermost aquifer. Using the average hydraulic conductivity for shallow wells (23.8 m/d [78 ft/d]) gives a groundwater velocity of 0.14 m/d (0.45 ft/d).

4.12.4.5.3 Evaluation of Monitoring Well Network. The groundwater monitoring network at LLWMA-4 continues to satisfy the requirement for at least one upgradient and three downgradient wells. No additional monitoring wells are planned for this network.

4.12.5 Low-Level Waste Management Area 5

4.12.5.1 LLWMA-5 Facility Overview. This waste management area contains future burial ground 218-W-6 and is located in the north-central portion of the 200 West Area (Figures 1-1 and 4.12-7). LLWMA-5 has not yet received any waste. This facility will consist of 35 trenches and cover approximately 18.0 ha (44.5 acres). At this time the trenches are planned to be used for mixed waste. LLWMA-5 is within the 200-ZP-3 source operable unit and the 200-ZP-1 groundwater operable unit.

4.12.5.2 LLWMA-5 Summary of 1993 Activities. Statistical analyses were performed on the groundwater chemistry data to determine baseline conditions. The data used for these calculations were from the first four quarters of sampling at the groundwater monitoring wells installed in 1991. These wells are now on a semiannual sampling schedule. Wells installed in 1992 are being sampled quarterly. Water level measurements are made quarterly at LLWMA-5 monitoring wells. Wells 299-W6-2 and 299-W7-10 are also part of the LLWMA-3 monitoring network and are sampled quarterly for the LLWMA-3 assessment program. Water level measurements are made monthly at these two wells.

4.12.5.3 LLWMA-5 Sampling and Analysis Program. Groundwater sampling for LLWMA-5 began in 1992. Table 4.12-8 lists wells in the RCRA monitoring network for LLWMA-5. Indicator evaluation sampling is on a semiannual basis for constituents listed in Table 4.12-2.

4.12.5.4 LLWMA-5 Groundwater Chemistry.

4.12.5.4.1 Constituents of Concern. The required statistics were calculated and the critical means for the indicator parameters were not exceeded by any monitoring well in the LLWMA-5 network. Carbon tetrachloride and nitrate exceeded the DWSs in several wells. Both constituents are associated with documented plumes in the 200 West Area (Section 4.1; Johnson 1993; WHC 1992b). Trichloroethylene has been reported above the 5-ppb DWS in wells 299-W6-10 and 299-W11-31.

Tritium is also present in concentrations above the DWS at monitoring wells on the eastern side of LLWMA-5. A downward trend is apparent in the wells with the highest concentrations (299-W6-10 and 299-W11-31).

As with many RCRA wells on the Hanford Site, unfiltered chromium, iron, and manganese are often above the DWS. Filtered samples did not have elevated levels of these metals (see Section 2.2.4).

Figure 4.12-7. Low-Level Waste Management Area 5.

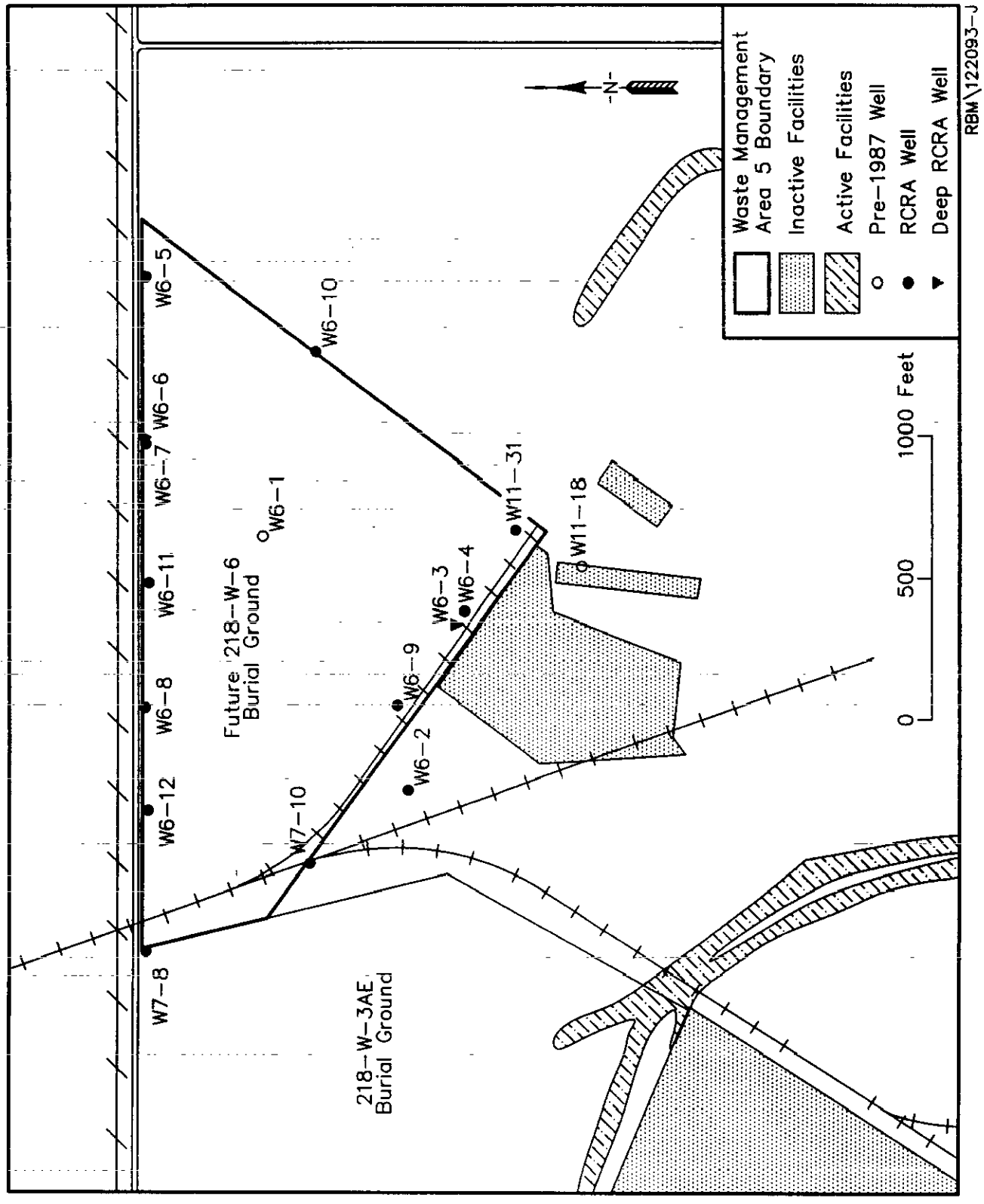


Table 4.12-8. Low-Level Waste Management Area 5 Monitoring Network.

Well	Aquifer	Sampling frequency	Water levels	Well standards	Other networks
299-W6-2[87]	Top of unconfined	Q	M	RCRA	LLWMA-3
299-W6-3[91]	Deep unconfined	SA	Q	RCRA	--
299-W6-4[91]	Top of unconfined	SA	Q	RCRA	--
299-W6-5[91]	Top of unconfined	SA	Q	RCRA	--
299-W6-6[91]	Deep unconfined	SA	Q	RCRA	--
299-W6-7[91]	Top of unconfined	SA	Q	RCRA	--
299-W6-8[91]	Top of unconfined	SA	Q	RCRA	--
299-W6-9[92]	Top of unconfined	Q	Q	RCRA	--
299-W6-10[92]	Top of unconfined	Q	Q	RCRA	--
299-W6-11[92]	Top of unconfined	Q	Q	RCRA	--
299-W6-12[92]	Top of unconfined	Q	Q	RCRA	--
299-W7-10[90]	Top of unconfined	Q	M	RCRA	LLWMA-3
299-W11-31[92]	Top of unconfined	Q	M	RCRA	--

Notes: Shading denotes upgradient wells. Superscript following well number denotes the year of installation.
M = frequency on a monthly basis.
Q = frequency on a quarterly basis.
RCRA = well is in compliance with RCRA standards.
SA = frequency on a semiannual basis.

4.12.5.4.2 Statistical Evaluation. Statistical evaluations of data for the past year at the LLWMA-5 consisted of establishing initial background levels and comparisons between upgradient and downgradient wells for any indication of contamination in the groundwater underlying the facility. Statistical analyses required by 40 CFR 265.93(b) and WAC 173-303-400 were performed on the samples collected from 1988 to July 1989 for shallow upgradient wells. Results are presented in Table 4.12-9. This table lists the background average, background standard deviation, critical mean (or range, in the case of pH) for the four contamination indicator parameters from the upgradient well (or wells) and upgradient/downgradient comparison values. The upgradient/downgradient comparison value (or range) is the value to which current and future averages of quadruplicate measurements are compared. Background tables are presented in Appendix C.

If the average for a parameter from a downgradient well exceeds the upgradient/downgradient comparison value listed in Table 4.12-9, that parameter is considered statistically different from background. If this is

Table 4.12-9. Critical Means Table for 44 Comparisons--Background Contamination Indicator Parameter Data for the Low-Level Waste Management Area 5.[a,b]

Constituent (unit)	n	df	t_c	Average background	Standard deviation	Critical mean	Upgradient/ downgradient comparison value
Specific conductance (μmho/cm)	24	23	4.086	519.562	167.372	1,217.6	1,217.6
Field pH	24	23	4.364	7.920	0.225	[6.92, 8.92]	[6.92, 8.92]
Total organic carbon (ppb)	18	17	4.330	480.6	49.67	701.6	800[d]
Total organic halogen[c] (ppb)	NC	NC	NC	NC	NC	NC	NC

[a]Data collected from December 1992 to September 1993 for upgradient wells 2-W6-9, 2-W6-10, and 2-W11-31; from May 1992 to May 1993 for well 2-W6-2; from September 1992 to June 1993 for well 2-W6-4; and from August 1992 to May 1993 for well 2-W7-10. Critical means calculated based on 44 comparisons.

[b]The following notations are used in this table:
df = degrees of freedom (n-1)
n = number of background replicate averages
t_c = Bonferroni critical t-value for appropriate df and 44 comparisons.

[c]Critical mean cannot be calculated because of problems associated with data quality.

[d]Upgradient/downgradient comparison value for total organic carbon is the limit of quantitation based on 1993 field blank data (see Appendix A).

NC = not calculated.

confirmed by subsequent verification sampling and analysis, the regulatory program is triggered into assessment. TOX was not evaluated due to problems associated with data quality. There were no exceedances in 1993.

4.12.5.5 LLWMA-5 Groundwater Flow.

4.12.5.5.1 Groundwater Flow Direction. The water table map for the 200 West Area presented in Figure 4.12-5 gives the best representation of the conditions beneath LLWMA-5. The groundwater flow direction beneath LLWMA-5 is to the northeast.

The vertical groundwater gradient in this area is most likely downward. Water levels in well 299-W6-3, which monitors the base of the unconfined aquifer, are generally 0.2 m (0.65 ft) less than water levels in well 299-W6-4. Water level measurements from shallow/deep paired wells 299-W6-6 and 299-W6-7 are inconclusive because the readings are within the normal margin of error associated with water level measurements.

4.12.5.5.2 Rate of Flow. An estimated hydraulic conductivity of 12 m/d (39 ft/d) was determined from the average for shallow wells completed in 1991 and 1992 (Mercer 1993a, 1993b). Using this estimate, the Darcy equation (equation 1), an effective porosity of 0.1, and an hydraulic gradient of 0.0015, a groundwater flow velocity of 0.18 m/d (0.59 ft/d) was calculated.

4.12.5.5.3 Evaluation of Monitoring Well Network. The groundwater monitoring network for LLWMA-5 complies with requirements for upgradient and downgradient wells. No additional groundwater monitoring wells are planned.

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4.13 SINGLE-SHELL TANKS

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4.13.1 Introduction

Although decommissioned in 1980, the single-shell tanks (SST) are considered to be actively storing hazardous and radioactive waste and have been designated as *Resource Conservation and Recovery Act of 1976* (RCRA) facilities. The groundwater beneath the SSTs is being monitored by an interim-status RCRA groundwater monitoring network that was initiated in 1989. There are now 35 RCRA-standard groundwater monitoring wells in the SST monitoring network; no wells were constructed this year. Three other wells, which monitor the top of the unconfined aquifer and that comply with construction standards in *Washington Administrative Code* (WAC) 173-160, are present around Waste Management Area (WMA) B-BX-BY and are suitable for collection of groundwater samples for analysis of hazardous and radioactive constituents. All SST waste management areas now comply with the RCRA requirement to have at least one upgradient and at least three downgradient wells. An additional 35 older carbon steel wells are used as screening wells, mostly for measurement of water levels. Table 4.13-1 lists the wells in the SST monitoring network.

Final disposition of SSTs and their contained waste is discussed in a closure/corrective action work plan submitted to Washington State Department of Ecology (Ecology) in 1989 (DOE-RL 1989). A revision of this closure plan was initiated in 1992 and amended in 1993, but was terminated before either revision was completed. Chapter 5.0 of DOE-RL (1989), on groundwater and groundwater monitoring, was revised in 1992. The SSTs are included in the following six operable units.

Waste Management Area	Operable unit
A-AX	200-PO-3[a]
C	200-PO-3[a]
B-BX-BY	200-BP-7
S-SX	200-RO-4[a]
T	200-TP-3
TX-TY	200-TP-5
U	200-UP-3

[a]Includes one or more adjoining double-shell tank farms.

Table 4.13-1. Groundwater Monitoring Wells for the Single-Shell Tanks. (sheet 1 of 4)

Well	Aquifer	Sampling frequency	Water levels	Well standards	Other networks
Waste Management Area A-AX					
299-E24-19[89]	Top of unconfined	S	M	RCRA	--
299-E24-20[90]	Top of unconfined	S	M	RCRA	--
299-E25-40[89]	Top of unconfined	S	M	RCRA	--
299-E24-13[68]	Top of unconfined	--	M	PRE	--
299-E25-1[55]	Top of unconfined	--	M	PRE	--
299-E25-2[55]	Top of unconfined	--	M	PRE	--
299-E25-14[63]	Top of unconfined	--	M	PRE	--
299-E25-15[69]	Top of unconfined	--	M	PRE	--
299-E25-16[69]	Top of unconfined	--	M	PRE	--
299-E25-41[89]	Top of unconfined	S	M	RCRA	--
299-E25-46[92]	Top of unconfined	Q	M	RCRA	--
Waste Management Area B-BX-BY					
299-E33-31[89]	Top of unconfined	S	M	RCRA	--
299-E33-32[89]	Top of unconfined	S	M	RCRA	--
299-E33-33[89]	Top of unconfined	S	M	RCRA	--
299-E33-36[90]	Top of unconfined	S	M	RCRA	216-B-63
299-E33-41[90]	Top of unconfined	S	M	RCRA	--
299-E33-38[90]	Top of unconfined	S	M	RCRA	200-BP-1
299-E33-39[90]	Top of unconfined	S	M	RCRA	200-BP-1
299-E33-42[91]	Top of unconfined	S	M	RCRA	--
299-E33-43[91]	Top of unconfined	S	M	RCRA	--
299-E33-1[54]	Top of unconfined	--	M	PRE	--
299-E33-5[55]	Top of unconfined	--	M	PRE	--
299-E33-8[53]	Top of unconfined	--	M	PRE	--
299-E33-18[50]	Top of unconfined	--	M	PRE	--
299-E33-21[57]	Top of unconfined	--	M	PRE	--
299-E33-24[67]*	Top of unconfined	--	M	PRE	--

Table 4.13-1. Groundwater Monitoring Wells for the Single-Shell Tanks. (sheet 2 of 4)

Well	Aquifer	Sampling frequency	Water levels	Well standards	Other networks
Waste Management Area C					
299-E27-12[89]	Top of unconfined	S	M	RCRA	--
299-E27-13[89]	Top of unconfined	S	M	RCRA	--
299-E27-14[89]	Top of unconfined	S	M	RCRA	--
299-E27-15[89]	Top of unconfined	S	M	RCRA	--
299-E27-7[82]	Top of unconfined	S[s]	M	PRE	--
Waste Management Area S-SX					
299-W22-39[90]	Top of unconfined	S	M	RCRA	--
299-W22-44[91]	Top of unconfined	S	M	RCRA	--
299-W22-45[92]	Top of unconfined	Q	M	RCRA	--
299-W22-46[91]	Top of unconfined	S	M	RCRA	--
299-W23-13[91]	Top of unconfined	S	M	RCRA	--
299-W23-14[90]	Top of unconfined	S	M	RCRA	--
299-W23-15[91]	Top of unconfined	S	M	RCRA	--
299-W23-1[53]	Top of unconfined	--	M	PRE	--
299-W23-2[54]	Top of unconfined	--	M	PRE	--
299-W23-3[56]	Top of unconfined	--	M	PRE	--
299-W23-4[57]	Top of unconfined	--	M	PRE	--
299-W23-5[69]	Top of unconfined	--	M	PRE	--
299-W23-6[69]	Top of unconfined	--	M	PRE	--
299-W23-7[60]	Top of unconfined	--	M	PRE	--
299-W23-8[82]	Top of unconfined	--	M	PRE	--
299-W23-12[70]	Top of unconfined	--	M	PRE	--

Table 4.13-1. Groundwater Monitoring Wells for the Single-Shell Tanks. (sheet 3 of 4)

Well	Aquifer	Sampling frequency	Water levels	Well standards	Other networks
Waste Management Area T					
299-W10-15[89]	Top of unconfined	Q+	M	RCRA	--
299-W10-16[89]	Top of unconfined	Q	M	RCRA	--
299-W11-27[91]	Top of unconfined	Q	M	RCRA	--
299-W11-28[91]	Top of unconfined	Q+	M	RCRA	--
299-W10-4[52]	Top of unconfined	--	M	PRE	--
299-W10-3[51]	Top of unconfined	--	M	PRE	--
299-W10-8[73]	Top of unconfined	--	M	PRE	--
299-W10-9[73]	Top of unconfined	--	M	PRE	--
299-W10-11[74]	Top of unconfined	--	M	PRE	--
299-W10-12[74]	Top of unconfined	--	M	PRE	--
299-W11-23[73]	Top of unconfined	--	M	PRE	--
299-W11-24[73]	Top of unconfined	--	M	PRE	--
299-W10-10[73]	Top of unconfined	--	M	PRE	--
Waste Management Area TX-TY					
299-W10-17[90]	Top of unconfined	Q	M	RCRA	--
299-W10-18[90]	Top of unconfined	Q	M	RCRA	--
299-W14-12[91]	Top of unconfined	Q	M	RCRA	--
299-W15-22[90]	Top of unconfined	Q	M	RCRA	--
299-W15-3[52]	Top of unconfined	--	M	PRE	--
299-W15-12[73]	Top of unconfined	--	M	PRE	--
299-W15-13[73]	Top of unconfined	--	M	PRE	--

Table 4.13-1. Groundwater Monitoring Wells for the Single-Shell Tanks. (sheet 4 of 4)

Well	Aquifer	Sampling frequency	Water levels	Well standards	Other networks
Waste Management Area U					
299-W18-25[90]	Top of unconfined	Q	M	RCRA	--
299-W18-30[91]	Top of unconfined	Q	M	RCRA	--
299-W18-31[91]	Top of unconfined	Q	M	RCRA	--
299-W19-31[90]	Top of unconfined	Q	M	RCRA	--
299-W19-32[90]	Top of unconfined	Q[+]	M	RCRA	--
299-W19-12[83]	Top of unconfined	Q[s]	M	PRE	--

Notes: Shading denotes upgradient wells. Superscript following well number denotes the year of installation.
M = frequency on a monthly basis.
PRE = well was constructed before RCRA specified standards.
Q = frequency on a quarterly basis.
RCRA = well is constructed to RCRA-specified standards.
S = frequency on a semiannual basis.
* = well decommissioned in September 1993.
+ = well is also sampled semiannually for the CCl_4 Expedited Response Action project.
s = well is sampled for supporting data.

Work plans for these *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) operable units will be prepared at a future date, which is not specified in the Action Plan that accompanies the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1992). Revision of the Tri-Party Agreement related to remediation/treatment of the SSTs and waste therein is currently in progress.

4.13.1.1 Facility Overview. The 149 SSTs are located in seven WMAs containing one or more tank farms. Three WMAs are in the 200 East Area (A-AX, B-BX-BY, and C) and four are located in the 200 West Area (S-SX, T, TX-TY, and U) (Figures 1-1, 4.13-1, and 4.13-2). Each tank farm contains from 4 (AX Tank Farm) to 18 (TX Tank Farm) tanks, each of which is an underground reinforced concrete tank with a single liner of carbon steel. The larger tanks have a diameter of 22.86 m (75 ft), varying height, and are buried at least 1.8 m (6 ft) below the ground surface.

The SSTs are actively storing metal, first- and second-cycle radioactive and hazardous (i.e., mixed) waste received from various processing facilities in the 200 Areas of the Hanford Site. Types of waste added to the SSTs and their general composition are discussed in Anderson (1990). These tanks were constructed between 1943 and 1964 and, depending on dimensions, each held

Figure 4.13-1. Single-Shell Tank Waste Management Areas in the 200 East Area.

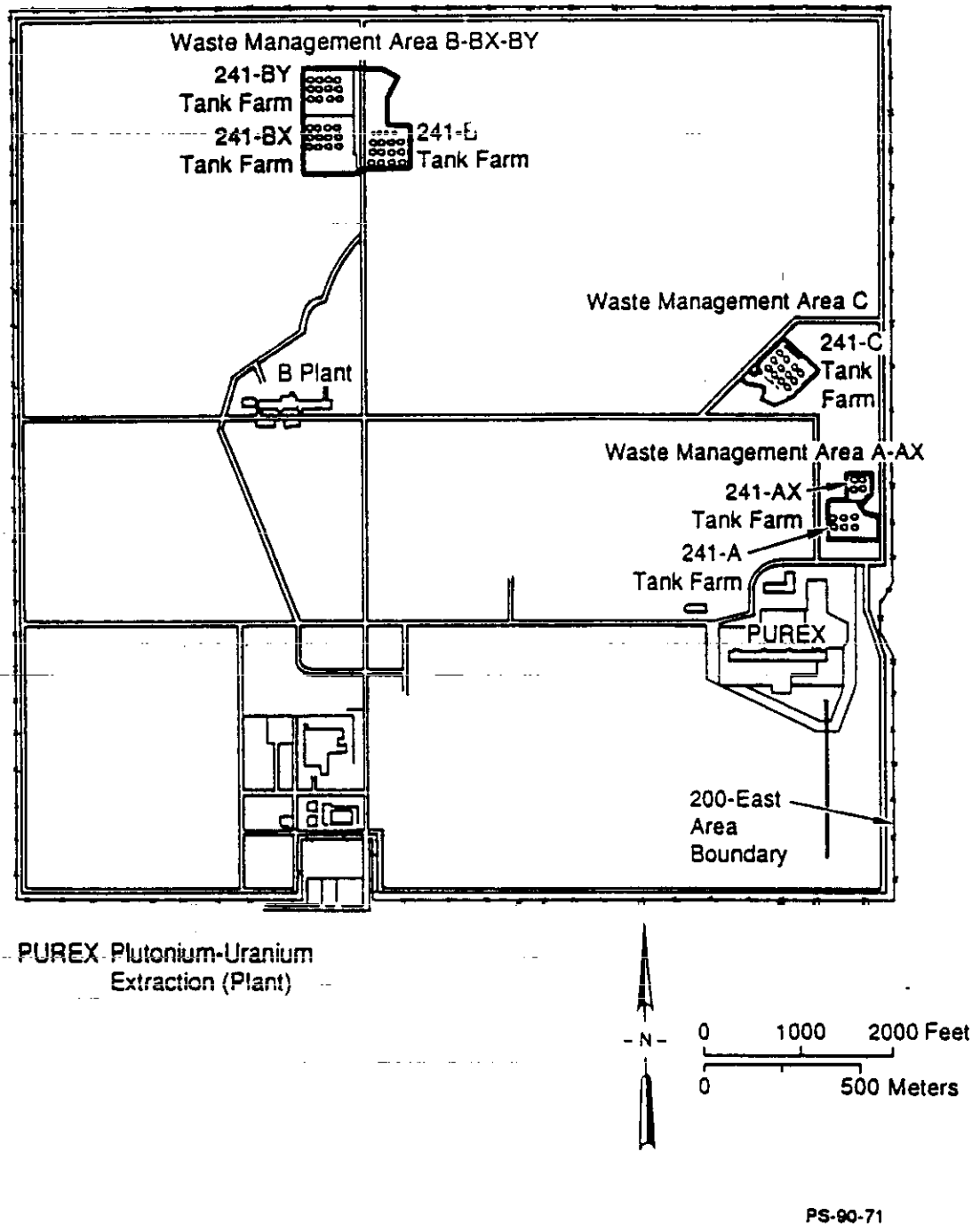
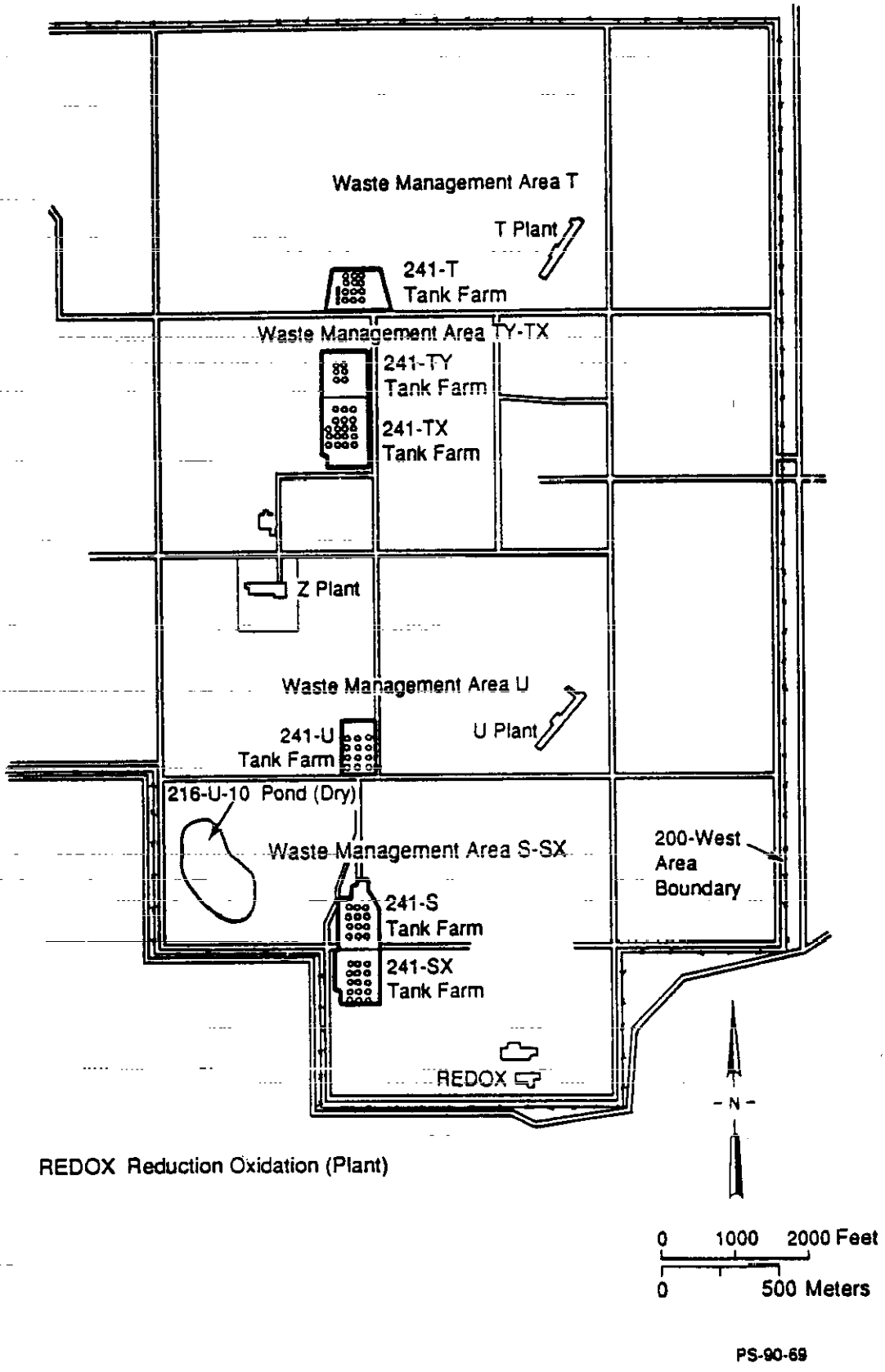


Figure 4.13-2. Single-Shell Tank Waste Management Areas in the 200 West Area.



REDOX Reduction Oxidation (Plant)

between 1,892,500 and 3,785,000 L (500,000 and 1,000,000 gal). The earliest tank farms (B, C, T, and U) each contain four smaller tanks (200-series tanks) that held 208,175 L (55,000 gal). The waste in the SSTs was generated by chemical processing of spent fuel rods from several reactors located in the 100 Areas of the Hanford Site, using the tributyl phosphate (TBP), bismuth phosphate ($BiPO_4$), Reduction-Oxidation (Plant) (REDOX) or Plutonium-Uranium Extraction (Plant) (PUREX) processes. Isotopes for various weapons systems were recovered in these processes and subsequently refined to weapons grade materials.

The SSTs received various mixtures of organic and inorganic liquids containing radionuclides, solvents, and metals that were originally discharged to the tanks as alkaline slurries. Waste management operations have mixed various waste streams from numerous processes and batches generated in processing spent fuel rods. Thus, the specific contents within each tank are difficult to determine because of this mixing and because of subsequent chemical reactions, degradation, and decay of radionuclides. The radionuclide and chemical inventory of the SSTs was summarized in a report this year (WHC 1993). Historical operations at the tank farms are summarized by Anderson (1990).

The last of the SSTs was removed from active service in 1980. Because discharges to the SSTs stopped in 1980, some of the tanks have been interim stabilized by removing the supernate and interstitial liquids to minimize the potential for leakage. Some tanks have been interim isolated by removing piping to prevent inadvertent addition of liquids to the tanks (see Hanlon [1993] for details).

Presently, the SSTs cumulatively store about 140,045,000 L (37 Mgal) of waste that consists mostly of salt cake and sludge (the residue from pumping out free liquids to the double-shell tanks), but with small quantities of supernate and interstitial liquids that could not be removed by pumping. The waste is largely inorganic and consists primarily of sodium hydroxide, sodium salts of nitrate, nitrite, carbonate, aluminate, and phosphate. Some hydrous oxides of iron and manganese also are present. Fission-product radionuclides (such as ^{137}Cs, ^{90}Sr, ^{99}Tc) and actinide elements (such as uranium, thorium, plutonium, and neptunium) constitute the principal radioactive components of the waste. Some of the SSTs are "Watch List Tanks" because they contain ferrocyanide or organic salts, they could possibly release hydrogen, or generate high heat from the radioactive decay of contents (see Hanlon [1993] for details).

The liners of the SSTs are made of carbon steel, which was not stress relieved during fabrication. Consequently, heat-induced stress-corrosion cracking of the liners has occurred and, along with other stresses from changing liquid levels and temperatures within the tanks, has resulted in the failure of some of the steel liners and the escape of liquids from some of the tanks. Of the 149 SSTs, 67 are assumed to be leaking (Hanlon 1993), with the largest known leaks occurring at Tank 241-T-106 in 1973 (estimated at 435,275 L [115,000 gal]) and Tank 241-BX-102 in 1971 (estimated at 264,950 L [70,000 gal]). Most leaks are estimated to be considerably smaller. Water was added to some tanks to control temperatures (e.g., Tank 241-A-105) and some of this water also may have leaked from the tanks. The earliest leaks at the SSTs were detected in the late 1950's. The most recent addition to the

list of assumed leakers was made in May 1993 when Tank 241-SX-102 was declared an assumed leaker; however, after further investigation using improved technology, the tank was again declared sound in July 1993 (Hanlon 1993).

The depth to groundwater beneath the tanks exceeds 30.3 m (100 ft), and it is not certain that any contaminants in the groundwater in the Separations Areas were derived from the waste leaked from the SSTs or whether they were from nearby unlined waste disposal facilities like cribs, trenches, or ponds, which received liquid wastes containing similar constituents. Analyses of gross gamma logs from dry wells adjacent to Tank 241-T-106 indicate that the leaked waste appeared to stabilize in the vadose zone well above the groundwater (Routson et al. 1979). The maximum detected depth of the 1-pCi/L concentration of ^{106}Ru (following the T-106 leak) was 28.8 m (95 ft) above the regional water table. Modeling studies using ^{106}Ru (Smoot et al. 1989) suggest that some of the leaked waste from Tank 241-T-106 may have reached groundwater.

The tanks are monitored through the use of liquid observation wells and other liquid monitoring devices in the tanks to detect changing liquid levels as well as a series of vertical wells in the unsaturated zone ("dry" wells) around the periphery of each tank. Two of the tank farms (A and SX) have a series of three lateral lines beneath each tank extending from a 3.6-m-(12-ft-) diameter vertical caisson. These dry wells and laterals are periodically monitored by gross gamma probes to detect elevated (above background) radioactive decay counts and to observe any changes in the detected peaks (increasing, decreasing, movement to greater depth, etc.). In 1993, the policy for leak detection at the SSTs changed. Gross gamma logging in external dry wells is no longer used to detect leaks at SSTs, although logging will continue temporarily until liquid observation wells (LOW) have been installed in all 149 SSTs. Currently LOWs exist in 56 tanks; logging in the LOWs along with measurement of liquid levels in the tanks by Food Instrument Corporation or manual tapes will be the primary leak detection system.

Stratigraphy beneath tank farms in the 200 Areas is generally summarized in Chapter 2.0. Greater detail of the stratigraphy beneath the 200 Areas may be found in Section 4.1, which also contains numerous cross sections through the 200 Areas. Details of stratigraphy beneath each WMA may be found in the groundwater monitoring plan for the SSTs (Jensen et al. 1989; Caggiano and Goodwin 1991). In general, network groundwater monitoring wells in the 200 East Area are screened in the Hanford formation (WMA B-BX-BY) or the Ringold Formation (WMAs A-AX and C). Wells in all WMAs in the 200 West Area are screened in the Ringold Formation (mostly Ringold E gravels, previously designated mostly as the Middle Ringold).

4.13.1.2 Summary of 1993 Activities. All but one of the existing RCRA wells were sampled in 1993, initially quarterly and then semiannually for most wells in most WMAs. Only well 2-W11-28 at WMA T was not sampled because of pump and well problems that were remediated late in the year. The data are reported in quarterly reports (Caggiano 1993b, 1993c, 1993d, 1994). Water levels were measured monthly in all the RCRA standard wells as well as most of the 35 carbon steel wells that are used only for water level measurements. Concern for safety of operating personnel led to exclusion of workers from tank farms except for priority work in August 1993. Consequently, water

levels were not measured in older carbon steel wells located inside the perimeter fences of tank farms after July 1993. Water level data for these 68 wells are also included in the quarterly reports (Caggiano 1993b, 1993c, 1993d, 1994). Water levels are no longer measured in decommissioned well 2-E33-24 (WMA B-BX-BY).

A borehole summary report containing geologic and geophysical logs along with as-built summaries for SST groundwater monitoring wells constructed in 1991 and 1992 (Caggiano 1993e) was released in March 1993.

Elevated specific conductance in downgradient wells 2-W10-15 at WMA T and 2-W10-17 and 2-W14-12 at WMA TX-TY, which exceeded the critical mean for this parameter, triggered WMAs T and TX-TY into groundwater quality assessment monitoring under interim status (40 *Code of Federal Regulations* [CFR] 265). The elevation of specific conductance was verified in April 1993. A groundwater quality assessment monitoring plan (Caggiano and Chou 1993) was submitted to Ecology in early July following notification to Ecology of the change in the status of groundwater monitoring at these two WMAs. A single groundwater quality assessment plan was submitted because these two WMAs (T and TX-TY) are close to one another and are situated above an areally widespread plume of high conductivity in groundwater in the northern part of the 200 West Area (Johnson 1993, Figure 5-37). Additional existing wells are being added to the assessment monitoring network to help determine whether the elevated conductivity in groundwater beneath these two WMAs results from releases from these two WMAs.

Field specific conductance in downgradient well 2-W22-44 (WMA S-SX) exceeded the critical mean in September 1993. However, the data proved to be erroneous after review and verification sampling, and no change in groundwater monitoring status has occurred. The laboratory measurement of specific conductance for the September 1993 sample was 190 μmho/cm and agrees with historical trends. There were no other exceedances of the critical mean (or critical range for pH) for any indicator parameters at SST WMAs in 1993 other than that at WMAs T and TX-TY discussed above.

An Engineering Change Notice to the groundwater monitoring plan for the SSTs was issued in September 1993 to update the plan with new figures, tables, and maps, and to modify the constituent list.

4.13.1.3 Other Activities in 1993. A borehole was constructed in 1993 adjacent to Tank 241-T-106 through the plume of waste leaked to soils in June 1973. Borehole 2-W10-196 was drilled using cable tool methods to a depth of 54.8 m (179.8 ft) and terminated about 11 m (35 ft) above the water table. A borehole characterization report describing this activity is being prepared.

One older carbon steel well, 2-E33-24 (WMA B-BX-BY), was decommissioned in September 1993 to facilitate the construction of a cover over the adjacent 216-B-57 Crib as part of remedial activities at the 200-BP-1 operable unit. Water levels had been measured monthly in this well before its decommissioning.

4.13.2 Sampling and Analysis Program

Groundwater beneath the SSTs is being monitored by a RCRA interim-status groundwater monitoring well network as specified in the original groundwater monitoring plan (Jensen et al. 1989) and its revision (Caggiano and Goodwin 1991). During the past year, indicator parameter background values were established for SST WMAs T, TX-TY, and U. Indicator parameter evaluation monitoring is occurring at each WMA except for WMAs T and TX-TY, which are now in assessment monitoring. Background sampling and analyses have been completed at all WMAs, and statistical analyses of these data for WMAs T, TX-TY, and U are presented in Appendix C. Tables 4.13-2 through 4.13-8 present the critical mean for all WMAs. Critical means for WMAs A-AX, B-BX-BY, C, and S-SX have been revised from those originally presented in the 1992 annual report (Caggiano 1993a). Previous RCRA groundwater monitoring at the SSTs is summarized in other annual reports (Caggiano 1991a, 1992a).

4.13.2.1 Monitoring Well Network. A total of 38 RCRA standard wells monitor the SSTs, 3 of which are part of other monitoring networks surrounding WMA B-BX-BY (see Table 4.13-1). An additional 35 older carbon steel wells have been used to measure water levels. Groundwater monitoring wells are shown in Figures 4.13-3 and 4.13-4 and are listed in Table 4.13-1. All RCRA standard wells are located outside the perimeter fences of the tank farms and at least 30.3 m (100 ft) from the nearest tank (per agreement with Ecology). This agreement was to avoid drilling through contaminants in the unsaturated zone and driving them to groundwater during well construction. As a further precaution, cable tool drilling is initiated with 30.5-cm- (12-in.-) (or larger) diameter casing so that any string of casing can be terminated in a zone of contamination (or perched water) and the well drilling can be continued with smaller diameter casing inside (if drilling is continued after an evaluation of field data). The first 12 RCRA groundwater monitoring wells were installed in 1989 at WMAs A-AX, B-BX-BY, C, and T, with 11 more installed in 1990 at WMAs A-AX, B-BX-BY, S-SX, TX-TY, and U. Ten additional wells were constructed at the SSTs in 1991 at WMAs B-BX-BY, S-SX, T, TX-TY, and U, and two were constructed in 1992 at WMAs A-AX and S-SX.

Fifty-one wells constructed of carbon steel casing before 1986 penetrate the uppermost unconfined aquifer within 302.8 m (1,000 ft) of the SSTs. Some of these wells are located within the tank farms (i.e., inside the perimeter fences). The casing in these wells is perforated at various lengths and intervals to communicate with the unconfined aquifer. When constructed, these wells generally lacked annular or surface seals and do not have nonreactive screens and filter packs surrounding the screens as required by WAC 173-160 for newly constructed monitoring wells. Partial annular seals were installed in some of these wells in the 1970's. Many of these wells have been used to measure water levels around the SSTs (see Table 4.13-1). Concerns for safety of personnel led to banning access to tank farms for nonessential activities in August 1993. Because of this standdown, water levels are no longer measured in wells located within the perimeter fences of tank farms pending evaluation to determine the added value of water level data from these wells.

4.13.2.2 Sampling and Analysis. Sampling of groundwater began in February 1990 in wells that were completed in 1989 and in some existing wells, but this activity was terminated in May 1990 because of the lack of a

Table 4.13-2. Critical Means Table for 20 Comparisons--Background Contamination Indicator Parameter Data for the Single-Shell Tanks Waste Management Area A-AX.[a,b]

Constituent (unit)	n	df	t_c	Average background	Standard deviation	Critical mean	Upgradient/ downgradient comparison value
Specific conductance (μmho/cm)	8	7	5.4079	396.563	59.671	738.8	738.8
Field pH	8	7	6.0818	7.798	0.194	[6.55, 9.05]	[6.55, 9.05]
Total organic carbon (ppb)	6[c]	5	5.4079	500	NC	NC	800[d]
Total organic halogen[e] (ppb)	NC	NC	NC	NC	NC	NC	NC

[a]Data collected from July 1991 to May 1992 for upgradient wells 2-E25-40 and 2-E25-41. Critical means calculated based on 20 comparisons.

[b]The following notations are used in this table:

df = degrees of freedom (n-1)

n = number of background replicate averages

t_c = Bonferroni critical t-value for appropriate df and 20 comparisons.

[c]Excluding total organic carbon values collected on 2/28/92 from wells 2-E25-40 and 2-E25-41 because of a nonconformance report.

[d]Upgradient/downgradient comparison value for total organic carbon is the limit of quantitation based on 1993 field blank data (see Appendix A).

[e]Critical mean cannot be calculated because of problems associated with data quality.

NC = not calculated.

Table 4.13-3. Critical Means Table for 28 Comparisons--Background Contamination Indicator Parameter Data for the Single-Shell Tanks Waste Management Area B-BX-BY.[a,b]

Constituent (unit)	n	df	t_c	Average background	Standard deviation	Critical mean	Upgradient/ downgradient comparison value
Specific conductance (μmho/cm)	8	7	5.7282	262.656	16.958	365.7	365.7
Field pH	8	7	6.4295	7.902	0.709	[3.07, 12.74]	[5.47, 10.78][c]
	7[c]	6	7.2227	8.126	0.344	[5.47, 10.78]	
Total organic carbon (ppb)	8	7	5.7282	500	NC	NC	800[d]
Total organic halogen[e] (ppb)	NC	NC	NC	NC	NC	NC	NC

[a]Data collected from July 1991 to June 1992 for upgradient wells 2-E33-33 and 2-E33-36. Critical means calculated based on 28 comparisons.

[b]The following notations are used in this table:

df = degrees of freedom (n-1)

n = number of background replicate averages

t_c = Bonferroni critical t-value for appropriate df and 28 comparisons.

[c]Upgradient/downgradient comparison value for pH is the critical mean calculated excluding the inconsistent pH replicate average 6.335 of samples collected on 1/3/92 from well 2-E33-36.

[d]Upgradient/downgradient comparison value for total organic carbon is the limit of quantitation based on 1993 field blank data (see Appendix A).

[e]Critical mean cannot be calculated because of problems associated with data quality.

NC = not calculated.

Table 4.13-4. Critical Means Table for 16 Comparisons--Background Contamination Indicator Parameter Data for the Single-Shell Tanks Waste Management Area C.[a,b]

Constituent (unit)	n	df	t_c	Average background	Standard deviation	Critical mean	Upgradient/ downgradient comparison value
Specific conductance (μmho/cm)	4	3	11.9838	353.063	14.244	543.9	543.9
Field pH	4	3	15.1451	8.038	0.109	[6.19, 9.88]	[6.19, 9.88]
Total organic carbon (ppb)	4	3	11.9838	500	NC	NC	800[c]
Total organic halogen[d] (ppb)	NC	NC	NC	NC	NC	NC	NC

[a]Data collected from July 1991 to August 1992 for upgradient well 2-E27-14. Critical means calculated based on 16 comparisons.

[b]The following notations are used in this table:

df = degrees of freedom (n-1)
n = number of background replicate averages
t_c = Bonferroni critical t-value for appropriate df and 16 comparisons.

[c]Upgradient/downgradient comparison value for total organic carbon is the limit of quantitation based on 1993 field blank data (see Appendix A).

[d]Critical mean cannot be calculated because of problems associated with data quality.

NC = not calculated.

Table 4.13-5. Critical Means Table for 28 Comparisons--Background Contamination Indicator Parameter Data for the Single-Shell Tanks Waste Management Area S-SX.[a,b]

Constituent (unit)	n	df	t_c	Average background	Standard deviation	Critical mean	Upgradient/ downgradient comparison value
Specific conductance (μmho/cm)	8	7	5.3168	246.3125	42.666	486.9	486.9
Field pH	7	6	6.4295	7.918	0.307	[5.81, 10.03]	[6.68, 9.18][c]
Total organic carbon (ppb)	8	7	5.3168	500	NC	NC	800[d]
Total organic halogen[e] (ppb)	NC	NC	NC	NC	NC	NC	NC

[a]Data collected from October 1991 to July 1992 for upgradient wells 2-W23-13 and 2-W23-14. Critical means calculated based on 28 comparisons.

[b]The following notations are used in this table:

df = degrees of freedom (n-1)
n = number of background replicate averages
t_c = Bonferroni critical t-value for appropriate df and 28 comparisons.

[c]Upgradient/downgradient comparison value for pH were calculated using data collected from October 1991 to June 1993 (wells 2-W23-13 and 2-W23-14) because the critical range calculated using four quarters of data is too large to be meaningful.

[d]Upgradient/downgradient comparison value for total organic carbon is the limit of quantitation based on 1993 field blank data (see Appendix A).

[e]Critical mean cannot be calculated because of problems associated with data quality.

NC = not calculated.

Table 4.13-6. Critical Means Table for 12 Comparisons--Background Contamination Indicator Parameter Data for the Single-Shell Tanks Waste Management Area T.[a,b]

Constituent (unit)	n	df	t_c	Average background	Standard deviation	Critical mean	Upgradient/ downgradient comparison value
Specific conductance (μmho/cm)	5	4	7.5288	837	40.938	1,174.6	1,174.6
Field pH	5	4	9.0288	7.706	0.240	[5.33, 10.08]	[5.33, 10.08]
Total organic carbon (ppb)	4[c]	3	10.869	500	NC	NC	800[d]
Total organic halogen[e] (ppb)	NC	NC	NC	NC	NC	NC	NC

[a]Data collected from July 1991 to July 1992 for upgradient well 2-W10-16. Critical means calculated based on 12 comparisons.

[b]The following notations are used in this table:

df = degrees of freedom (n-1)

n = number of background replicate averages

t_c = Bonferroni critical t-value for appropriate df and 12 comparisons.

[c]Excluding total organic carbon values collected on 4/20/92 from well 2-W10-16 because of a nonconformance report.

[d]Upgradient/downgradient comparison value for total organic carbon is the limit of quantitation based on 1993 field blank data (see Appendix A).

[e]Critical mean cannot be calculated because of problems associated with data quality.

NC = not calculated.

Table 4.13-7. Critical Means Table for 16 Comparisons--Background Contamination Indicator Parameter Data for the Single-Shell Tanks Waste Management Area TX-TY.[a,b]

Constituent (unit)	n	df	t_c	Average background	Standard deviation	Critical mean	Upgradient/ downgradient comparison value
Specific conductance (μmho/cm)	4	3	11.984	454.812	15.866	667.4	667.4
Field pH	4	3	15.145	7.782	0.371	[1.5, 14.0]	[5.77, 9.67][c]
Total organic carbon (ppb)	3[d]	2	28.258	500	NC	NC	800[e]
Total organic halogen[f] (ppb)	NC	NC	NC	NC	NC	NC	NC

[a]Data collected from September 1991 to July 1992 for upgradient well 2-W15-22. Critical means calculated based on 16 comparisons.

[b]The following notations are used in this table:

df = degrees of freedom (n-1)
n = number of background replicate averages
t_c = Bonferroni critical t-value for appropriate df and 16 comparisons.

[c]Upgradient/downgradient comparison values for pH were calculated using data collected from September 1991 to September 1993 (well 2-W15-22) because the critical range calculated using four quarters of data is too large to be meaningful.

[d]Excluding total organic carbon values collected on 4/20/92 from well 2-W15-22 because of a nonconformance report.

[e]Upgradient/downgradient comparison value for total organic carbon is the limit of quantitation based on 1993 field blank data (see Appendix A).

[f]Critical mean cannot be calculated because of problems associated with data quality.

NC = not calculated.

Table 4.13-8. Critical Means Table for 20 Comparisons--Background Contamination Indicator Parameter Data for the Single-Shell Tanks Waste Management Area U.[a,b]

Constituent (unit)	n	df	t_c	Average background	Standard deviation	Critical mean	Upgradient/ downgradient comparison value
Specific conductance (μmho/cm)	8	7	5.4079	239.562	29.216	407.1	407.1
Field pH	8	7	6.0818	7.772	0.490	[4.61, 10.93]	[5.53, 10.29][c]
	7[c]	6	6.7883	7.909	0.328	[5.53, 10.29]	
Total organic carbon (ppb)	7[d]	6	5.9588	500	NC	NC	800[e]
Total organic halogen[f] (ppb)	NC	NC	NC	NC	NC	NC	NC

[a]Data collected from April 1992 to March 1993 for upgradient wells 2-W18-25 and 2-W18-31. Critical means calculated based on 20 comparisons.

[b]The following notations are used in this table:

df = degrees of freedom (n-1)
n = number of background replicate averages
t_c = Bonferroni critical t-value for appropriate df and 20 comparisons.

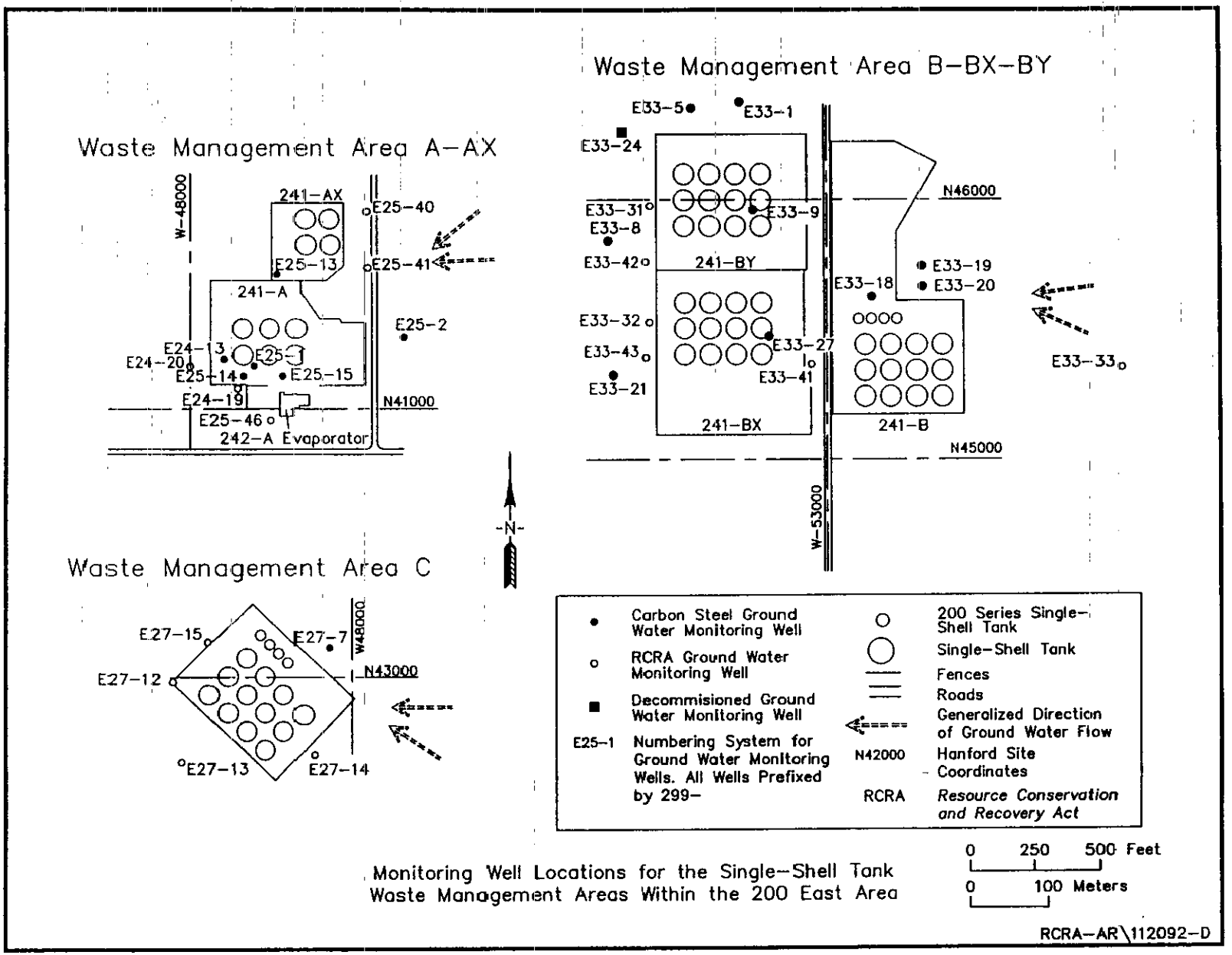
[c]Upgradient/downgradient comparison value for pH is the critical mean calculated excluding the inconsistent pH replicate average 6.822 of samples collected on 7/20/92 from well 2-W18-25.

[d]Excluding total organic carbon values collected on 4/21/92 from well 2-W18-25 because of a nonconformance report.

[e]Upgradient/downgradient comparison value for total organic carbon is the limit of quantitation based on 1993 field blank data (see Appendix A).

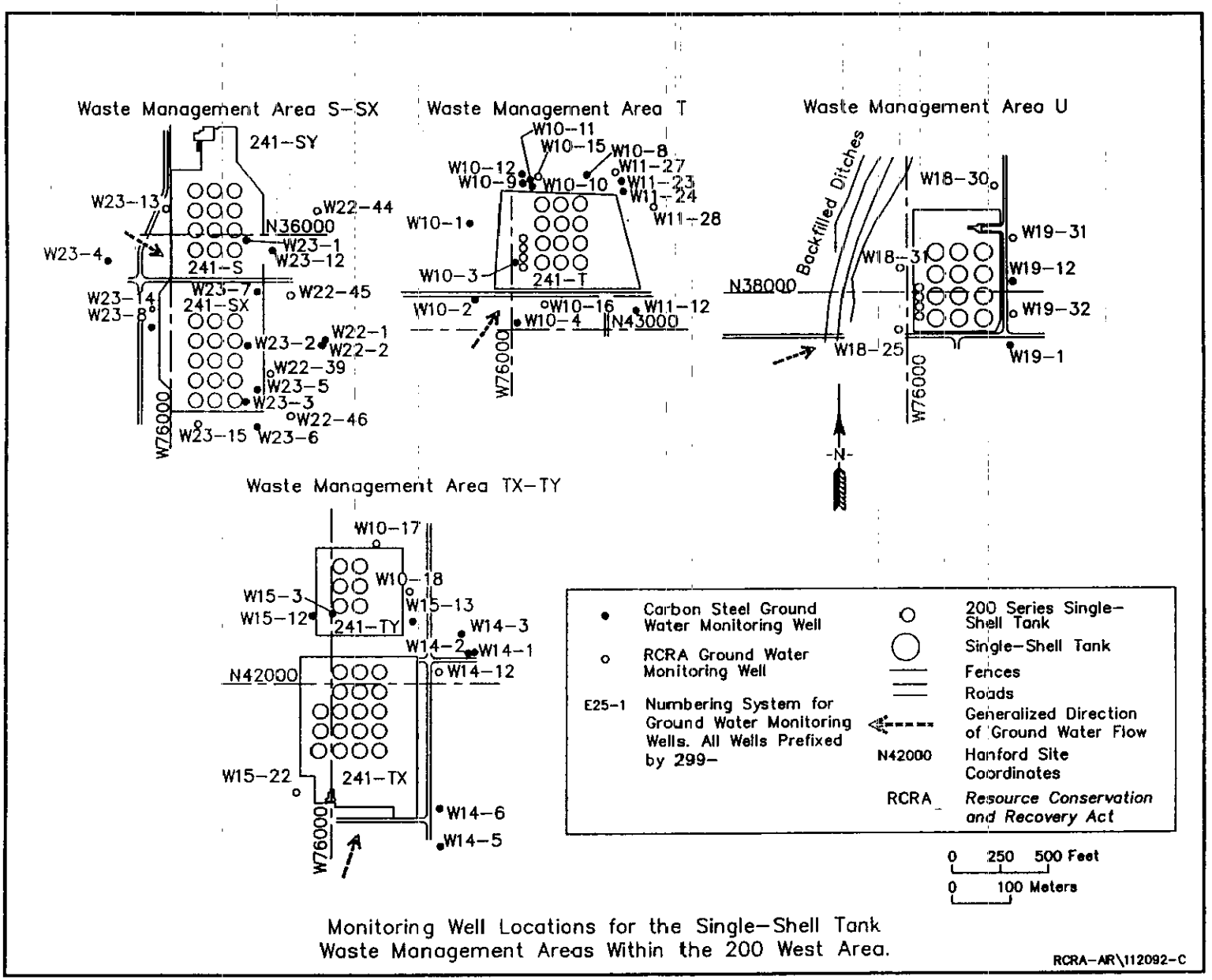
[f]Critical mean cannot be calculated because of problems associated with data quality.

NC = not calculated.



Monitoring Well Locations for the Single–Shell Tank Waste Management Areas Within the 200 East Area

Figure 4.13-3. Monitoring Well Locations for the Single-Shell Tank Waste Management Areas in the 200 East Area.



Monitoring Well Locations for the Single-Shell Tank Waste Management Areas Within the 200 West Area.

Figure 4.13-4. Monitoring Well Locations for the Single-Shell Tank Waste Management Areas in the 200 West Area.

supporting analytical laboratory. Quarterly sampling of wells in WMAs A-AX, B-BX-BY, C, and T was resumed in July 1991. Wells in WMAs S-SX, TX-TY, and U were first sampled in October 1991. Analytical data have been reported in quarterly reports (Caggiano 1991a, 1991b, 1991c, 1991d, 1992b, 1992c, 1992d, 1992e). Four quarters of background data have been obtained at all WMAs. Groundwater is now sampled semiannually at WMAs A-AX, B-BX-BY, C, S-SX, and U and analyzed for indicator parameters. Annual sampling for analysis of groundwater quality and site-specific parameters occurs at these five WMAs also. Because of the potential for detecting the spread of a groundwater mound that may be developing beneath the 284-W Powerhouse Pond, anions have been added to the site-specific constituent list for WMA U and are sampled quarterly. Chloride is the best tracer of groundwater recharged from infiltration beneath the pond.

Groundwater samples from SST monitoring wells were analyzed for drinking water standards (DWS), indicator parameters, and water quality parameters (Table 4.13-9) during the period of background monitoring. Samples were also analyzed for ^{137}Cs, ^{90}Sr, ^{99}Tc, ^{60}Co, and tritium as these were among the key radionuclides discharged to the SSTs. Iodine-129 is analyzed semiannually as a part of another program and the data are included for the SSTs. Total uranium and plutonium are also monitored. Gamma scans were also run on samples from SST wells. All SST WMAs are now in indicator parameter evaluation status (except for WMAs T and TX-TY), and are sampled semiannually for indicator parameters and annually for groundwater quality parameters and site-specific parameters. Anions are sampled quarterly at WMA U to determine whether changing water levels result from expansion of a water table mound beneath the 284-W Powerhouse Pond.

4.13.3 Groundwater Chemistry Evaluation

4.13.3.1 Possible Sources. The site-specific constituents identified above continue to be monitored during indicator parameter evaluation. Because these constituents were also discharged to nearby cribs, unlined specific-retention trenches, unlined ditches, french drains, and ponds (some of which are upgradient of SST tank farms), it is not possible to distinguish the source of these contaminants in groundwater. There are no known unique indicator analytes that would allow tracing of contaminants directly to the SSTs as a source. Supernatant from the last tank in a cascade line was discharged to nearby cribs at times to make space for additional discharges to the SSTs. Some of this waste may have reached groundwater.

Quality control for some analyses of ^{99}Tc in the laboratory in 1992 has led to the reporting of erroneously high activities. After a review of laboratory procedure, it was discovered that dilution was not properly factored into the calculation of activity of this isotope and several values were corrected in a subsequent quarterly report. Others of these high values still remain anomalously high and review of the data is continuing.

4.13.3.2 Elevated Constituents. A number of constituents have exceeded regulatory limits in RCRA groundwater monitoring wells at SST WMAs. These exceedances are summarized in Table 4.13-10. Note that results of unfiltered analyses for iron, chromium, and manganese are not included in this table

Table 4.13-9. Constituent List for the Single-Shell Tanks.

Contamination indicator parameters		
pH	Total organic carbon	
Specific conductance	Total organic halogen	
Groundwater quality parameters		
Chloride	Manganese	Sodium
Iron	Phenols	Sulfate
Drinking water parameters		
2,4-D	Endrin	Methoxychlor
2,4,5-TP Silvex	Fluoride	Nitrate
Arsenic	Gross alpha	Radium
Barium	Gross beta	Selenium
Cadmium	Lead	Silver
Chromium	Lindane	Toxaphene
Coliform bacteria	Mercury	Turbidity
Site-specific parameters		
Ammonium	Total organics:	Tritium
	Cesium-137	
	Cobalt-60	
	Gamma scan	
	Iodine-129	
	Plutonium	
	Strontium-90	
	Uranium	

because these constituents are common in groundwater samples collected from recently constructed RCRA standard wells at all facilities on the Hanford Site. These constituents occur mostly in analyses of unfiltered samples, but are sometimes found in analyses of filtered samples. Iron, chromium, and manganese are generally not indicative of any waste leaked to soils from the SSTs, but are principal constituents in carbon steel and stainless steel. For these reasons, these constituents are assumed to occur in analyses of groundwater because of well construction or some other common element. Turbidity in samples often exceeds the WAC standard of 1 nephelometric turbidity unit (NTU), but is not included in this table. All SST WMAs in the 200 East Area are located above a plume of ^{129}I that has been mapped in groundwater (Connelly et al. 1992a). Iodine-129 is therefore omitted from this table. Most values for ^{129}I in groundwater from 200 East Area SST wells are between 1 and 10 pCi/L (see plume map for ^{129}I in Section 4.1).

Table 4.13-10. Constituents Exceeding Regulatory Limits[a] at Single-Shell Tank Waste Management Areas. (sheet 1 of 3)

WMA	Well No.	Up/Down Gradient	Constit.	Value[c]	Standard[b]	Date(s)	Comments
A-AX	E24-19	D	Fil. Cr	1,800 280 960	100 100 100	11/05/92 3/03/93 6/17/93	Values for unfiltered nickel for these sample dates are: 930,960; 210,210; 340 ppb filtered nickel results: 790,800; 140,150; 300 ppb
			Fil. Mn	140	50	11/05/92	--
			Turbid.	1.5 NTU 17.0 NTU	1 NTU	11/05/92 11/05/92	--
B-BX-BY	E33-31	D	Gross β	104 pCi/L 105 pCi/L 139 pCi/L	50 50 50	11/06/92 3/02/93 6/16/93	Values for ^{99}Tc for these sample dates are: 104, 462, and 139 pCi/L
	E33-41	D	Gross β	125 pCi/L 110 pCi/L 117 pCi/L	50 50 50	11/06/92 3/02/93 6/17/93	Values for ^{99}Tc for these sample dates are: 577, 397, and 647 pCi/L
	E33-42	D	Gross β	110 pCi/L 126 pCi/L 102 pCi/L 108 pCi/L	50 50 50 50	11/06/92 3/02/93 6/17/93 9/21/93	Values for ^{99}Tc for these sample dates are: 460, 439, 449, and 408 pCi/L
C	E27-14	U	^{90}Sr	35.30 pCi/L	8	6/15/93	--
S-SX	W22-39	D	Gross β	181.00 pCi/L 165.0 pCi/L 168.0 pCi/L	50 50 50	11/24/92 3/04/93 6/24/93	Values for ^{99}Tc for these sample dates are: 677, 627, and 554 pCi/L
	W22-46	D	Gross β	244.0 pCi/L 203.0 pCi/L 208.0 pCi/L	50 50 50	11/23/92 3/05/93 6/24/93	Values for ^{99}Tc for these sample dates are: 865, 611, and 629 pCi/L
	W23-14	U	Tritium	155,000 pCi/L 206,000 pCi/L 165,000 pCi/L	20,000 20,000 20,000	11/23/92 3/04/93 6/25/93	--
	W23-15	D	Gross β	2,410 pCi/L 3,000 pCi/L 1,550 pCi/L 1,410 pCi/L	50 50 50 50	11/23/92 3/04/93 6/25/93 6/25/93	Values for ^{99}Tc for these dates: 7,320, 7,740, 7,040, and 6,550 pCi/L
			NO_3	68,000 76,000 73,000 73,000	45,000 45,000 45,000 45,000	11/23/92 3/04/93 6/25/93 6/25/93	--
			Tritium	247,000 pCi/L 238,000 pCi/L 165,000 pCi/L 167,000 pCi/L	20,000 20,000 20,000 20,000	11/23/92 3/04/93 6/25/93 6/25/93	--
T	W10-16	U	Tritium	40,800 pCi/L 51,700 pCi/L 50,000 pCi/L 46,100 pCi/L	20,000 20,000 20,000 20,000	11/10/92 3/05/93 6/21/93 9/28/93	--
			Conduct.	772 μmho/cm[d] 790 μmho/cm[d] 779 μmho/cm[d] 771 μmho/cm[d]	700 700 700 700	11/10/92 3/05/93 6/21/93 9/28/93	--
			NO_3	160,000 140,000 150,000	45,000 45,000 45,000	11/10/92 3/05/93 6/21/93	--

Table 4.13-10. Constituents Exceeding Regulatory Limits[a] at Single-Shell Tank Waste Management Areas. (sheet 2 of 3)

WMA	Well No.	Up/Down Gradient	Constit.	Value[b]	Standard[b]	Date(s)	Comments
T (cont)	W10-15[c]	D	Tritium	40,800 pCi/L 39,700 pCi/L 38,100 pCi/L 35,300 pCi/L	20,000 20,000 20,000 20,000	11/10/92 3/05/93 6/21/93 9/28/93	--
			Gross β	77.4 pCi/L 82.3 pCi/L 85.3 pCi/L 108.0 pCi/L	50 pCi/L 50 pCi/L 50 pCi/L 50 pCi/L	11/10/92 3/05/93 6/21/93 9/28/93	Values for ^{99}Tc for these sample dates are: 495, 301, 334, and 562 pCi/L
			Conduct.	1,244 µmho/cm[d] 1,180 µmho/cm[d] 1,183 µmho/cm[d] 1,172 µmho/cm[d]	700 700 700 700	11/10/92 3/05/93 6/21/93 9/28/93	--
			NO_3	410,000 370,000 360,000	45,000 45,000 45,000	11/10/92 3/05/93 6/21/93	--
			F	5,000 4,700 4,800	4,000 4,000 4,000	11/10/92 3/05/93 6/21/93	--
TX-TY	W10-17[c]	D	Tritium	44,100 pCi/L 44,600 pCi/L 41,600 pCi/L 38,600 pCi/L	20,000 20,000 20,000 20,000	11/11/92 3/08/93 6/23/93 9/28/93	--
			NO_3	140,000 120,000 130,000	45,000 45,000 45,000	11/11/92 3/08/93 6/23/93	--
			Conduct.	745 µmho/cm[d] 777 µmho/cm[d] 752 µmho/cm[d] 760 µmho/cm[d]	700 700 700 700	11/11/92 3/08/93 6/23/93 9/28/93	--
	W10-18	D	Tritium	34,300 pCi/L 25,100 pCi/L 23,400 pCi/L 22,800 pCi/L	20,000 20,000 20,000 20,000	11/11/92 3/08/93 6/24/93 9/28/93	--
			NO_3	61,000 49,000 54,000	45,000 45,000 45,000	11/13/92 3/08/93 6/23/93	--
	W14-12[c]	D	NO_3	530,000 440,000 470,000	45,000 45,000 45,000	11/11/92 3/09/93 6/23/93	--
			Tritium	463,000 pCi/L 456,000 pCi/L 427,000 pCi/L 564,000 pCi/L	20,000 20,000 20,000 20,000	11/11/92 3/09/93 6/23/93 9/28/93	--
			Conduct.	1,639 µmho/cm[d] 1,505 µmho/cm[d] 1,571 µmho/cm[d]	700 700 700	11/11/92 3/03/93 6/23/93	--
			Gross β	1,680 pCi/L 905 pCi/L 1,890 pCi/L 1,220 pCi/L	50 50 50 50	11/11/92 3/09/93 6/23/93 9/28/93	Values for ^{99}TC for these sample dates are: 13,300, 10,700, 7,570, and 12,200 pCi/L
	W15-22	U	NO_3	64,000 68,000 82,000	45,000 45,000 45,000	11/11/92 3/05/93 6/23/93	--

Table 4.13-10. Constituents Exceeding Regulatory Limits[a] at Single-Shell Tank Waste Management Areas. (sheet 3 of 3)

WMA	Well No.	Up/Down Gradient	Constit.	Value[b]	Standard[b]	Date(s)	Comments
U	W19-31	D	Gross β	65.8 pCi/L 50.4 pCi/L 50.9 pCi/L	50 50 50	11/10/92 3/04/93 6/21/93	Values for ^{99}Tc for these sample dates are: 257, 168, and 195 pCi/L
	W19-32	D	Gross β	102.0 pCi/L 118.0 pCi/L	50 50	11/13/92 3/05/93	Values for ^{99}Tc for these sample dates are: 483 and 439 pCi/L

[a]Excludes values of chromium, iron, and manganese that frequently exceeded the drinking water or secondary maximum contaminant level standards for analyses of unfiltered samples. Only results of filtered analyses of these metals that exceeded standards are reported. These metals are constituents of carbon steel and stainless steel, materials used to drill and construct wells. Elevated values for these constituents in unfiltered analyses are common in all RCRA standard wells constructed at all RCRA facilities at the Hanford Site over the last several years. Based on this pattern of occurrence, it is assumed that these constituents in groundwater are present because of well construction practices or some factor common to all wells. They are generally not indicative of constituents discharged to specific waste management facilities and are therefore judged not to be a result of contamination of the groundwater by discharge of waste to facilities. For these reasons, these constituents are excluded from this table. Turbidity is also excluded because it is elevated above the 1-NTU level in most wells.

[b]In units of ppb unless otherwise noted.

[c]Mean value of quadruplicate analyses exceeds the WAC 248-54-175 limit and the critical mean for specific conductance. High conductivity in this well has triggered the site into groundwater quality assessment monitoring under 40 CFR 265.

[d]Average of four readings at well head.

NTU = nephelometric turbidity unit.

WMA = Waste Management Area.

Chromium in filtered analyses of groundwater in well 2-E24-19 at WMA A-AX has been erratic (Figure 4.13-5). This constituent exhibited a steady rise to 1,800 ppb in November 1992, declined to 280 ppb in March 1993, and then rose again to 960 ppb in June. Results for filtered analyses of nickel and manganese have shown similar trends, but the concentrations have been lower. No other constituents appear to exhibit this trend and there has been no significant change in pH or specific conductance to accompany this change. This is the only downgradient well at WMA A-AX exhibiting this trend; nearby wells 2-E24-20 and 2-E25-46 do not exhibit these changes in concentration of chromium in filtered sample analyses. There have been no new leaks or spills of dangerous waste reported in either the 241-A or 241-AX Tank Farms that might account for this phenomenon. Some special studies are being considered to evaluate the pattern of changing chromium concentrations in this well.

Groundwater contaminant plumes beneath the 200 Areas have been mapped (Ford 1993). Contaminants in groundwater include constituents discharged to SSTs. These same constituents were also discharged to unlined cribs, ditches, french drains, and ponds at lower activity levels. There are no known unique indicator contaminants that trace solely to the SSTs as a source. Therefore, it is not possible to state unequivocally that the SSTs have not contaminated groundwater. A similar point was made by Caggiano (1991e) regarding the fate of cooling water added to Tank 241-A-105 between 1971 and 1978. Routson et al. (1979) demonstrated that contaminants leaked from Tank 241-T-106, the largest known tank leak at the Hanford Site, did not reach the water table and had stabilized in the vadose zone. While it is not known whether contaminants leaked from any of the SSTs have penetrated the entire vadose zone to reach

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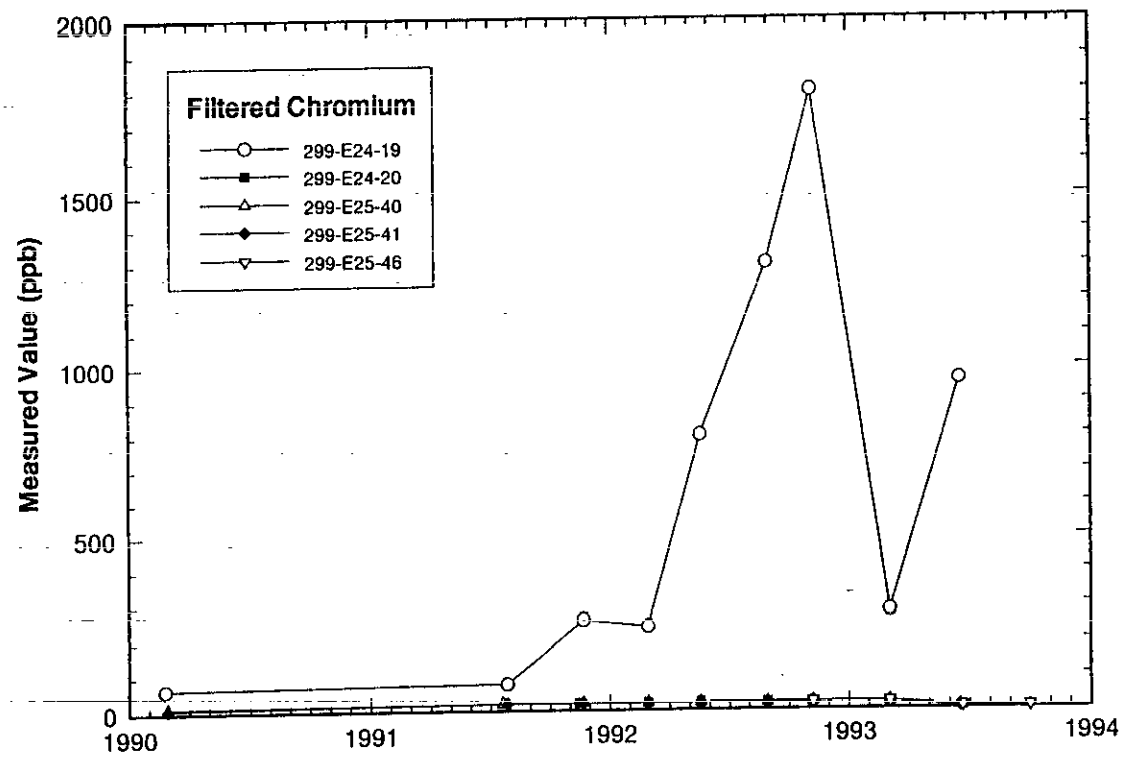

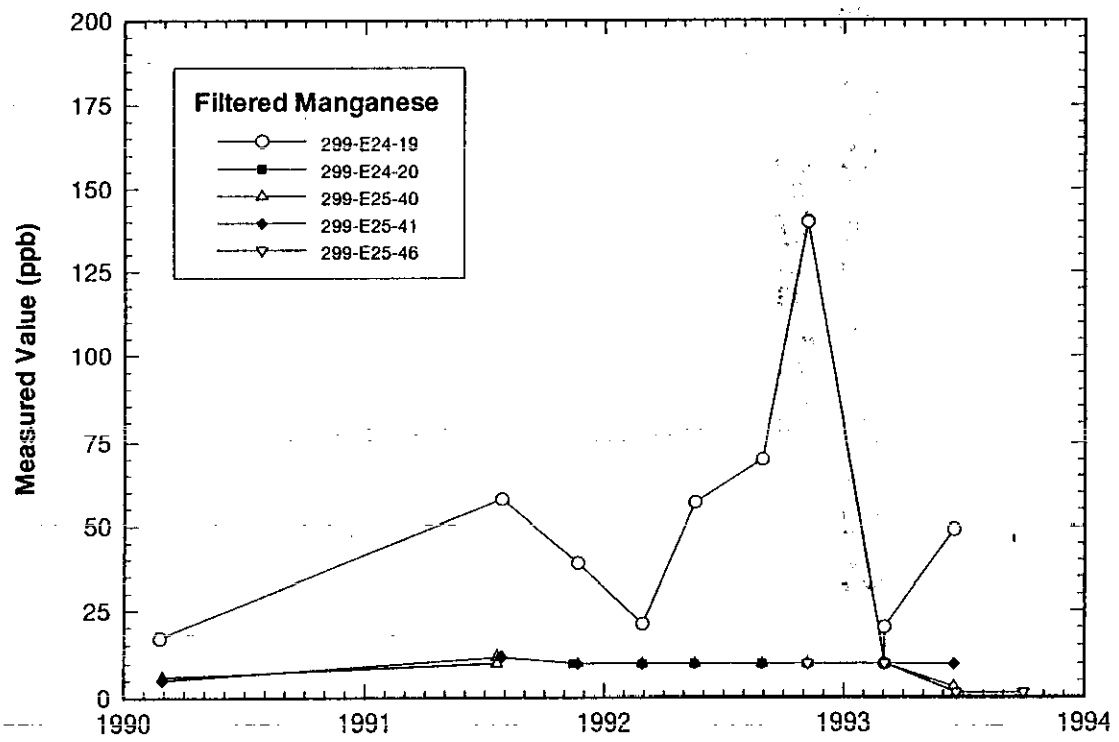

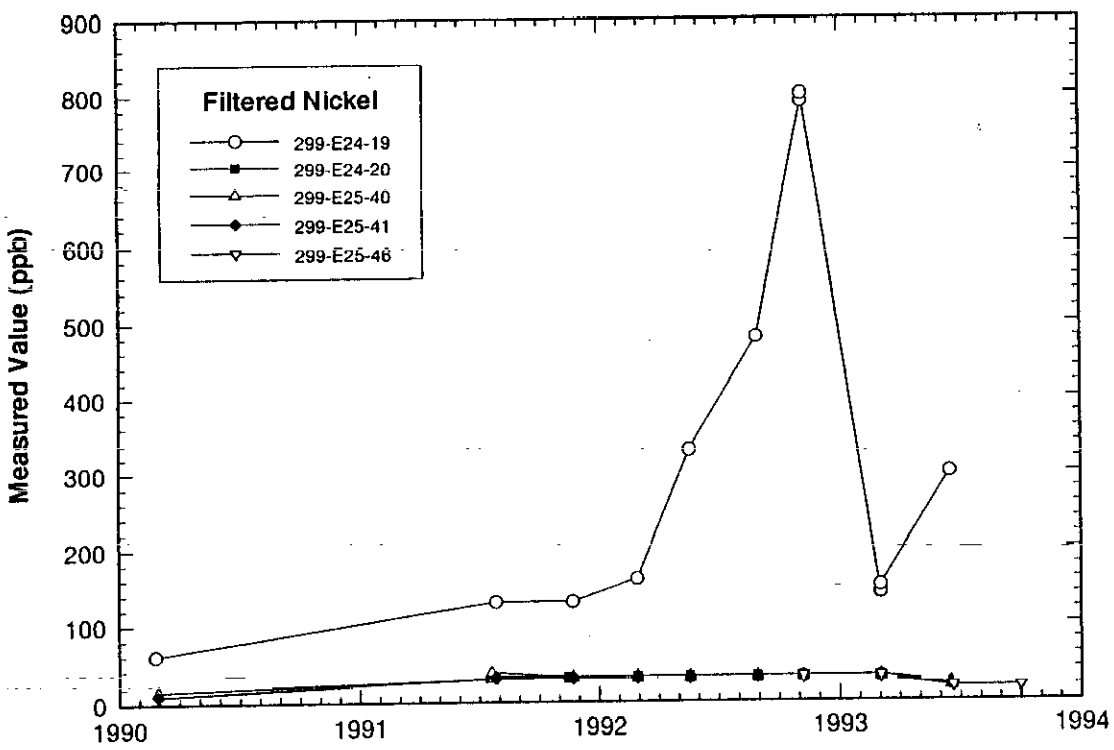

Figure 4.13-5. Filtered Chromium, Manganese, and Nickel Versus Time for Well 2-E24-19.

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groundwater, it is known that supernatant was pumped from the last tank in a cascade line of SSTs to cribs during earlier operations at the Hanford Site. Whether the SSTs have contributed to contamination of groundwater at the Hanford Site remains equivocal.

As stated in Section 4.13.1, field specific conductance in downgradient well 2-W10-15 at WMA T, along with wells 2-W10-17 and 2-W14-12 at WMA TX-TY, has exceeded the critical mean for this parameter and has triggered these sites into groundwater quality assessment monitoring under 40 CFR 265. Field specific conductance in these wells has historically been high during RCRA sampling and continues to be elevated. Quarterly sampling during a joint assessment monitoring program for these two WMAs will attempt to determine the source analyte(s) accounting for the elevated field specific conductance and whether the SSTs in WMAs T and TX-TY may be the source. Analytical data obtained from RCRA sampling/analyses suggest that elevated chloride, fluoride, sodium, nitrate, and sulfate, individually or collectively, are constituents that may be affecting the conductivity of groundwater in this area of the 200 West Area. Elevated specific conductance is areally widespread in groundwater in the northern part of the 200 West Area (see Johnson 1993, Figure 5-37).

No specific trends in analyte concentration/activity have been noted during RCRA sampling/analyses. A general decrease in concentration/activity of analytes can be seen in data when comparing results from analyses performed in the 1950's, 1960's, and 1970's with those performed during RCRA sampling/analyses. However, the methods of analyses have changed and the construction of the older carbon steel wells and the section of the unconfined aquifer sampled differs significantly so as to be able to make only generalizations. Older wells have perforated carbon steel casing ranging from 6 to 30+ m (20 to 100+ ft), have no annular seal or filter pack, have experienced varying degrees of development, and may have been sampled by varying types of pumps or bailers during their history. The data are therefore not directly comparable. Contaminants elevated in Table 4.13-10 generally have been elevated to varying degrees in nearby older carbon steel wells at varying times during their sampling history.

To evaluate contamination in groundwater beneath the SSTs relative to total contamination of groundwater in the 200 Areas, the reader is referred to contaminant plume maps elsewhere in this report or those contained in Ford (1993).

4.13.3.3 Statistical Evaluation. Required statistical evaluations for all WMAs have been performed. During the past year, initial background levels were established for WMAs T, TX-TY, and U. Evaluations for WMAs T, TX-TY, and U are summarized below. Tables listing the background input data, replicate averages, and the background summary statistics are provided in Appendix C. Details of four quarters of background data for WMAs A-AX, B-BX-BY, C, and S-SX were included in the 1992 annual report (Caggiano 1993a). Updated critical means tables for WMAs A-AX, B-BX-BY, C, and S-SX are included here as Tables 4.13-2 through 4.13-5.

For all WMAs, the critical mean for total organic carbon (TOC) cannot be calculated because all of the background values taken from the upgradient well (or wells) for TOC are below the contractually required quantitation limit,

and an estimate for the background standard deviation is not available. For these sites, a limit of quantitation (LOQ) is calculated from the 1993 field blanks data. Following U.S. Environmental Protection Agency (EPA) guidance (EPA 1986), the LOQ will be used as the TOC upgradient/downgradient comparison value. This approach uses quality control data to target the limit of quantifiable data and provides a realistic approach for upgradient/downgradient comparisons. The LOQ for TOC (analyzed by DataChem Laboratories) is 800 ppb (see Appendix A for calculations).

For all WMAs, the critical mean for total organic halogen (TOX) is not calculated because of unsatisfactory audit findings relating to inadequate quality control of analytical procedures in performing these analyses in the laboratory (see Section 1.5.4).

4.13.3.3.1 Waste Management Area A-AX. There were no exceedances of the critical mean for field specific conductance, field pH, or TOC at WMA A-AX. Constituents that exceeded regulatory limits are listed in Table 4.13-10.

4.13.3.3.2 Waste Management Area B-BX-BY. There were no exceedances of the critical mean for field specific conductance, field pH, or TOC at WMA B-BX-BY. Constituents that exceeded regulatory limits are listed in Table 4.13-10.

4.13.3.3.3 Waste Management Area C. There were no exceedances of the critical mean for field specific conductance, field pH, or TOC at WMA C. Constituents that exceeded regulatory limits are listed in Table 4.13-10.

4.13.3.3.4 Waste Management Area S-SX. There were no exceedances of the critical mean for field specific conductance, field pH, or TOC at WMA S-SX other than the values for field specific conductance in well 2-W22-44 that were demonstrated to be erroneous. Constituents that exceeded regulatory limits are listed in Table 4.13-10.

4.13.3.3.5 Waste Management Area T. Statistical evaluation of data for the past year at WMA T consisted of establishing background levels for the contamination indicator parameters (except for TOX). Statistical analyses required by 40 CFR 265.93(b) and WAC 173-303-400 were performed on the samples collected from July 1991 to May 1992 for upgradient well 2-W10-16. Results are presented in Table 4.13-6. This table lists the background average, background standard deviation, and critical mean (or critical range, in the case of pH) for the contamination indicator parameters from the upgradient wells. The critical mean (or critical range) is the value to which future averages of quadruplicate measurements will be compared. As indicated in Section 4.13.3.2, critical mean for TOX was not calculated because meaningful results could not be obtained from the laboratory.

Other than specific conductance, there has been no exceedance of the critical mean (or critical range) for the other indicator parameters at WMA T. Exceedance of the critical mean for field specific conductance has triggered WMA T into groundwater quality assessment monitoring status under 40 CFR 265. Details are in Section 4.13.1.2 and Caggiano and Chou (1993).

4.13.3.3.6 Waste Management Area TX-TY. Statistical evaluation of data for the past year at WMA TX-TY consisted of establishing background levels for the contamination indicator parameters (except for TOX). Statistical analyses required by 40 CFR 265.93(b) and WAC 173-303-400 were performed on the samples collected from July 1991 to May 1992 for upgradient well 2-W15-22. Results are presented in Table 4.13-7. This table lists the background average, background standard deviation, and critical mean (or critical range, in the case of pH) for the contamination indicator parameters from the upgradient wells. The critical mean (or critical range) is the value to which future averages of quadruplicate measurements will be compared. As indicated in Section 4.13.3.2, the critical mean for TOX was not calculated because meaningful results could not be obtained from the laboratory.

Other than specific conductance, there has been no exceedance of the critical mean (or critical range) for the other indicator parameters at WMA TX-TY. Exceedance of the critical mean for field specific conductance has triggered WMA TX-TY into groundwater quality assessment monitoring status under 40 CFR 265. Details may be found in Section 4.13.1.2 and Caggiano and Chou (1993).

4.13.3.3.7 Waste Management Area U. Statistical evaluation of data for the past year at WMA U consisted of establishing background levels for the contamination indicator parameters (except for TOX). Statistical analyses required by 40 CFR 265.93(b) and WAC 173-303-400 were performed on the samples collected from July 1991 to May 1992 for upgradient wells 2-W18-25 and 2-W18-31. Results are presented in Table 4.13-8. This table lists the background average, background standard deviation, and critical mean (or critical range, in the case of pH) for the contamination indicator parameters from the upgradient wells. The critical mean (or critical range) is the value to which future averages of quadruplicate measurements will be compared. As indicated in Section 4.13.3.2, critical mean for TOX was not calculated because meaningful results could not be obtained from the laboratory.

There were no exceedances of the critical mean for field specific conductance, field pH, or TOC at WMA U. Constituents that exceeded regulatory limits are listed in Table 4.13-10.

In future evaluations of analytical data obtained from groundwater samples, if the average from a downgradient well for a parameter exceeds the upgradient/downgradient comparison values in Tables 4.13-2 through 4.13-8, that parameter is considered statistically different from background. If this difference is confirmed by subsequent verification sampling and analysis, the regulatory program is triggered into assessment monitoring as has happened at WMAs T and TX-TY.

4.13.4 Evaluation of Water Levels

4.13.4.1 Water Level Data. Water levels have been measured monthly in all RCRA groundwater monitoring wells constructed in all WMAs, as well as in some older pre-RCRA wells. Water level measurements for 1993 may be found in quarterly reports of RCRA groundwater monitoring (Caggiano 1993b, 1993c, 1993d, 1994). Data from these wells for June 1993 are plotted in

Figures 4.13-6 and 4.13-7, which depict larger areas than individual WMAs so that the general direction of groundwater flow can be demonstrated. Across areas as small as most WMAs, the difference in water level elevation is less than 0.3 m (1 ft), and in many cases less than 0.15 m (0.5 ft) (Table 4.13-11). To show direction of flow, data from SST wells along with wells from other RCRA facilities have been combined into smaller scale maps of larger areas to illustrate the groundwater flow direction and gradient.

Water level declines between June 1992 and June 1993 around SST WMAs are tabulated in Table 4.13-11 for those wells in which more than 12 measurements have been made. Water levels are measured monthly in 68 wells. Water level data are presented in quarterly reports (Caggiano 1993b, 1993c, 1993d, 1994). General trends of water level can be seen on the hydrographs of 200 Area wells shown in Figures 4.13-8, 4.13-9, and 4.13-10.

From 1992 through 1993, the elevation of the water table has continued to decline beneath the 200 Areas because of reduced discharges to cribs, unlined trenches, and B Pond. As seen in Table 4.13-11, the decline is not consistently the same in all wells in a WMA. Declines in the elevation of the water table beneath the 200 West Area are generally greater than those beneath the 200 East Area. Variations in liquid discharges and differences in hydraulic conductivity may account for this head variability. Between June 1992 and June 1993 water levels beneath WMAs in the 200 East Area have declined about 20 to 21 cm (0.67 to 0.71 ft); water levels in the southern part of the 200 West Area have declined between 58 and 68 cm (1.9 to 2.2 ft). Groundwater beneath the northern part of the 200 West Area (WMAs T and TX-TY) declined by 19 to 25 cm (0.64 to 0.83 ft).

4.13.4.1.1 200 East Area Groundwater Flow Direction. For WMAs A-AX, B-BX-BY, and C, the controlling influence of groundwater flow is the mound in the water table beneath the 216-B-3 Pond (hereafter referred to as the B Pond mound). Discharges to B Pond have created this mound that has reversed the direction of flow from a west-to-east flow, which existed before Hanford Site operations, to an east-to-west flow across the northern part of the 200 East Area. Along with the high transmissivity of the Hanford formation, the B Pond mound creates a groundwater table in the 200 East Area that slopes very gently.

Figure 4.13-6 illustrates that a low saddle in the water table exists beneath the 200 East Area that has been created by both the regional eastward groundwater flow and the westward flow from the B Pond mound. Although difficult to demonstrate from water table elevations, long-term groundwater flow paths can be demonstrated by the migration of contaminant plumes from the area of the PUREX Plant as well as the 216-BY Cribs in the northern part of the 200 East Area. Groundwater flow in the unconfined aquifer from the northern part of the 200 East Area is to the north toward Gable Mountain, while groundwater flow in the unconfined aquifer from the southeastern part of the 200 East Area is to the southeast. The top of the basalt (i.e., the bottom of the unconfined aquifer in the 200 East Area) slopes to the south along the north flank of the Cold Creek syncline, the axis of which plunges southeast.

Figure 4.13-6. 200 East Area Water Table Map, June 1993.

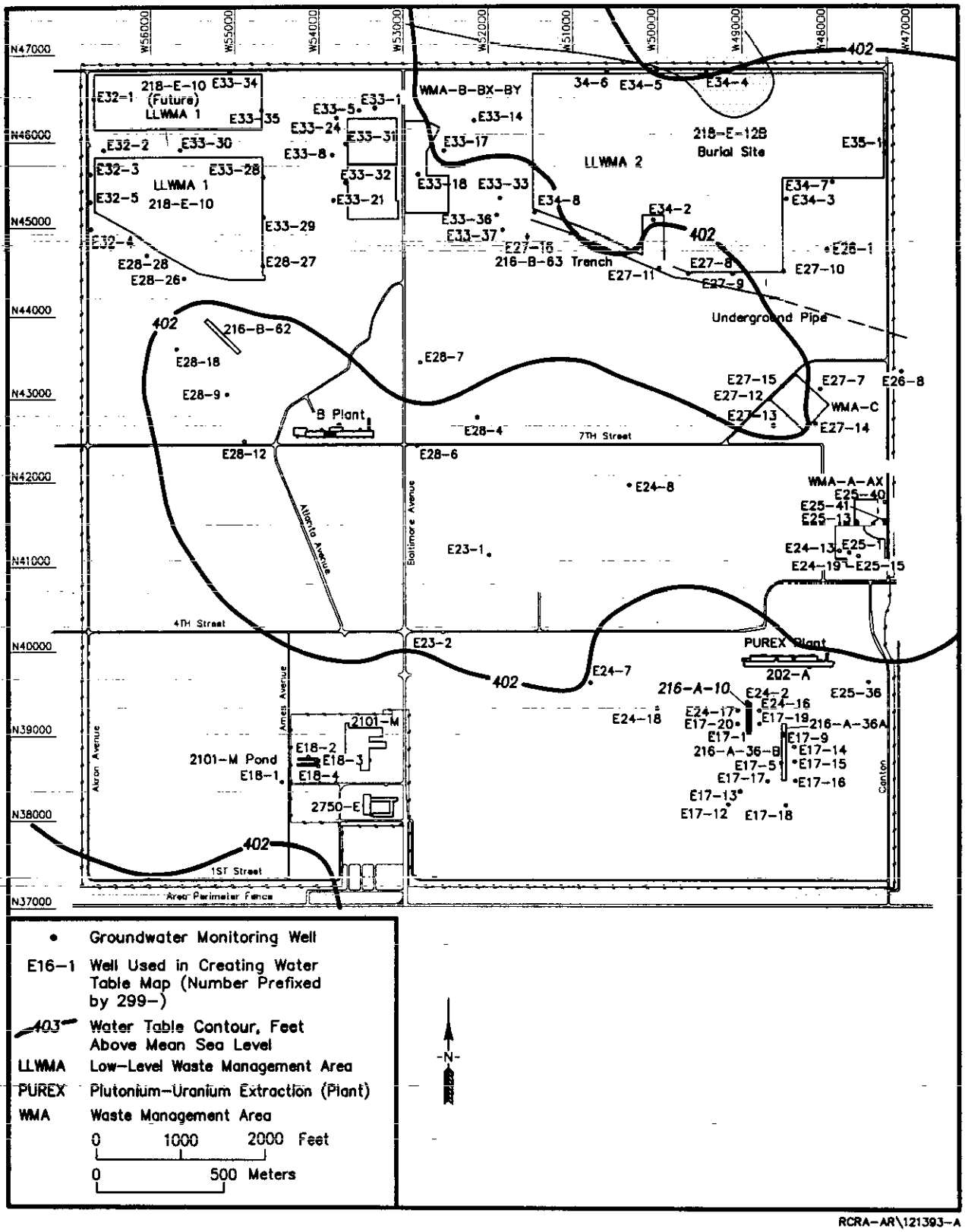

Figure 4.13-7. 200 West Area Water Table Map, June 1993.

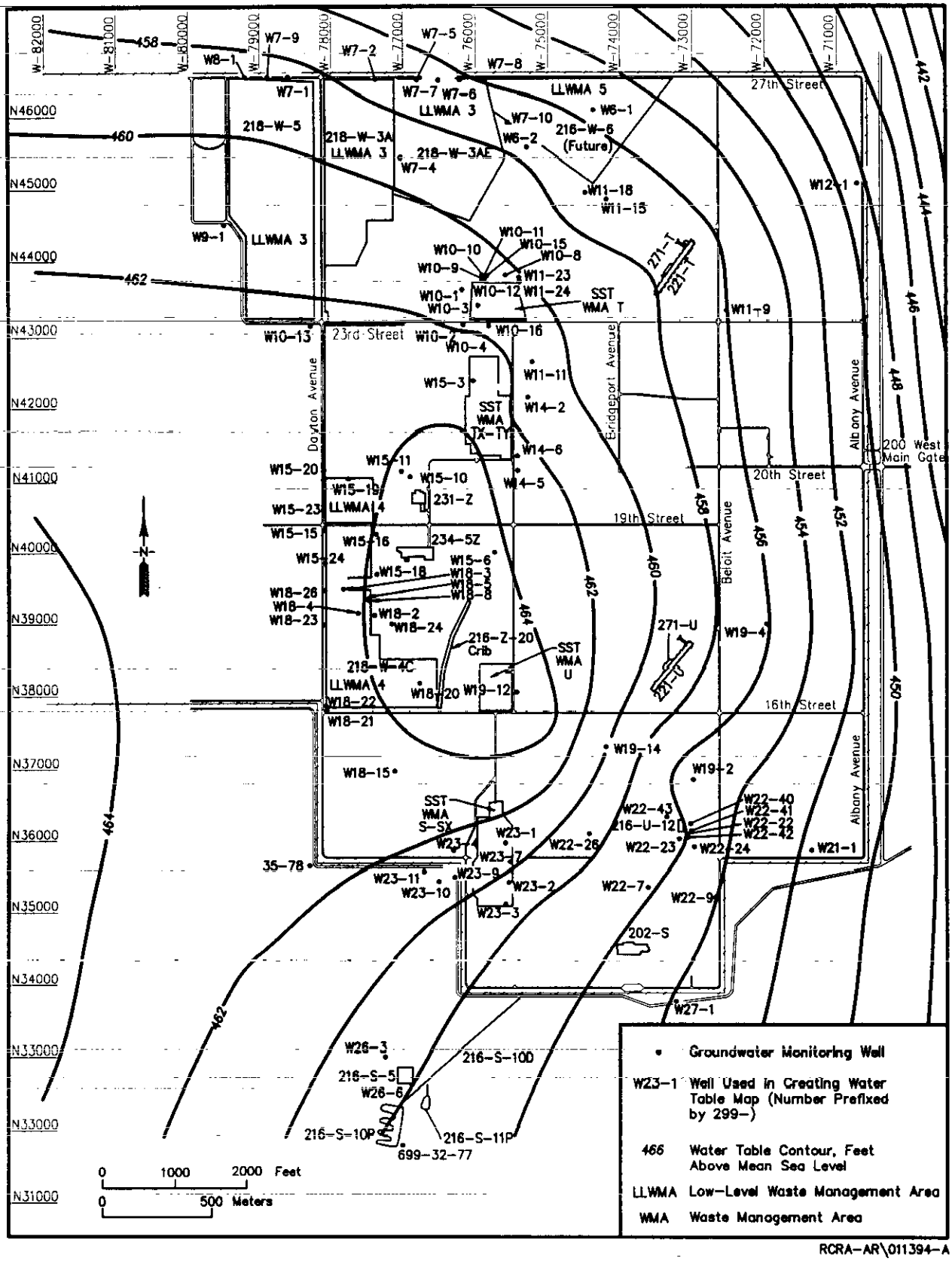

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Table 4.13-11. Water Level Decline Single-Shell Tank Groundwater Monitoring Wells. (sheet 1 of 2)

WMA	Well no.	6/90 - 6/91 Decline (ft)[a]	6/91 - 6/92 Decline (ft)[a]	6/92 - 6/93 Decline (ft)[a]
A-AX	E24-13	0.95	0.67	0.61
	E24-19	0.71	0.82	0.64
	E25-1	0.96	0.58	0.69
	E25-2	1.05	0.52	0.57
	E25-13	0.95	0.60	0.64
	E25-15	0.94	0.59	0.71
	E25-40	0.80	0.74	0.60
	E25-41	0.83	0.71	0.57
		Avg. 0.90	0.62	0.63
B-BX-BY	E33-8	0.80	0.70	0.63
	E33-18	0.81	--	--
	E33-21	0.77	0.73	0.70
	E33-24	1.11	0.75	1.0
	E33-31	0.77	0.73	0.77
	E33-32	0.71	0.75	0.70
	E33-33	0.61	0.80	0.77
	E33-41			0.75
	E33-42			0.54
	E33-43			0.57
		Avg. 0.80	0.74	0.71
C	E27-7	0.66	0.69	0.58
	E27-12	0.79	0.71	0.68
	E27-13	0.80	0.46	0.81
	E27-14	0.64	0.89	0.62
	E27-15	0.79	0.72	0.64
		Avg. 0.74	0.69	0.67
S-SX	W22-39	NA	1.57	1.93
	W22-44		--	2.01
	W22-45		--	--
	W22-46		--	1.85
	W23-1		1.51	2.16
	W23-2		1.35	2.29
	W23-3		1.30	2.07
	W23-6		1.37	2.12
	W23-7		2.24	2.28
	W23-8		1.58	2.47
	W23-12		1.49	2.56
	W23-13		1.93	2.67
	W23-14		1.58	2.33
	W23-15		--	--
		Avg.	1.59	2.23

Table 4.13-11. Water Level Decline Single-Shell Tank Groundwater Monitoring Wells. (sheet 2 of 2)

WMA	Well no.	6/90 - 6/91 Decline (ft)[a]	6/91 - 6/92 Decline (ft)[a]	6/92 - 6/93 Decline (ft)[a]
T	W10-3	1.72	1.45	0.76
	W10-8	1.70	1.87	0.52
	W10-9	1.90	--	0.71[b]
	W10-10	1.93	1.59	0.60
	W10-11	1.92	1.59	0.59
	W10-12	1.89	1.58	0.61
	W10-15	1.94	1.62	0.57
	W10-16	1.74	1.47	0.81
	W11-23	1.59	1.86	0.64
	W11-24	1.57	1.82	0.69
	W11-27	--	--	0.69
		Avg. 1.79	1.65	0.64
TX-TY	W10-17	NA	1.46	0.54
	W10-18		1.37	0.62
	W14-12		--	0.62
	W15-3		1.31	1.12
	W15-12		1.48	0.98
	W15-13		1.40	0.85
	W15-22		1.51	1.0
		Avg.	1.42	0.82
U	W18-25	NA	2.08	2.56
	W18-30		--	1.55
	W18-31		--	2.26
	W19-12		1.65	1.80
	W19-31		1.66	1.55
	W19-32		1.63	1.59
		Avg.	1.76	1.89

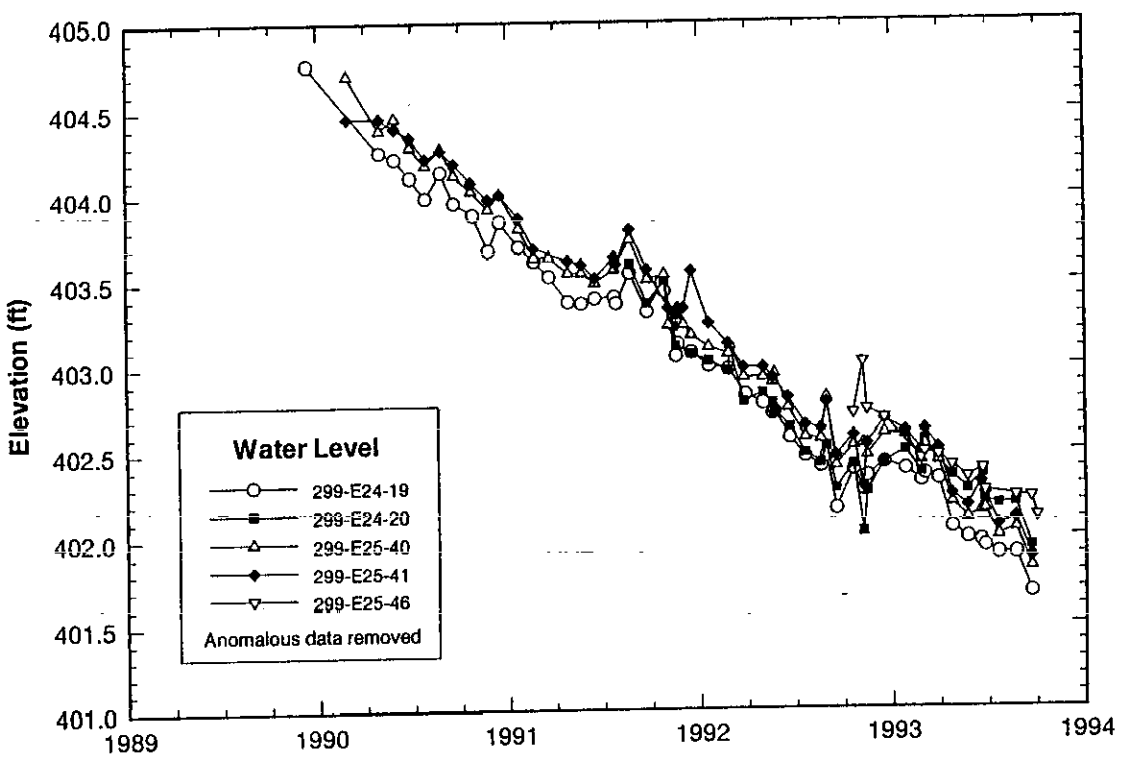
Notes: RCRA standard wells are shaded; upgradient wells are underlined.

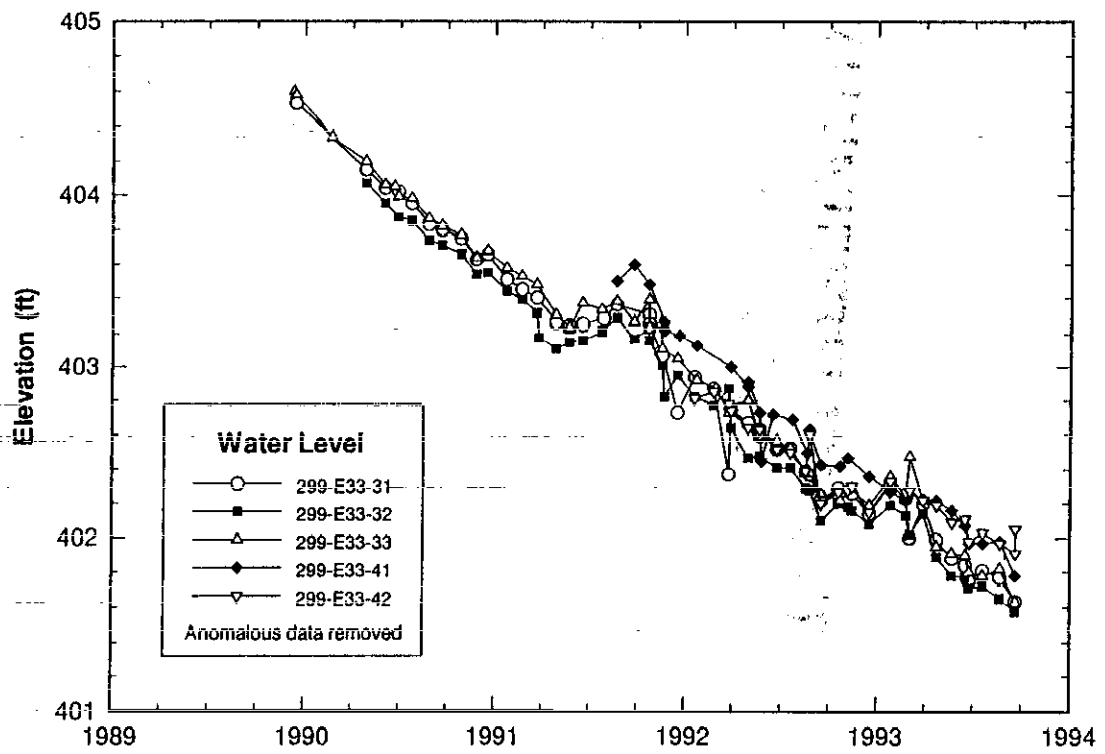
Additional wells are used for measurement of water levels, but measurements were not always made in each well each month. Water level measurements were not initiated until early 1993 in wells constructed in 1992. Changes in water levels in these wells will be reported next year.

[a]Measurements are made in feet and fractions thereof and are therefore reported in those units. To convert feet to meters, divide by 3.28.

[b]Data from July 1992 to June 1993 (June data not available).

NA = not available.





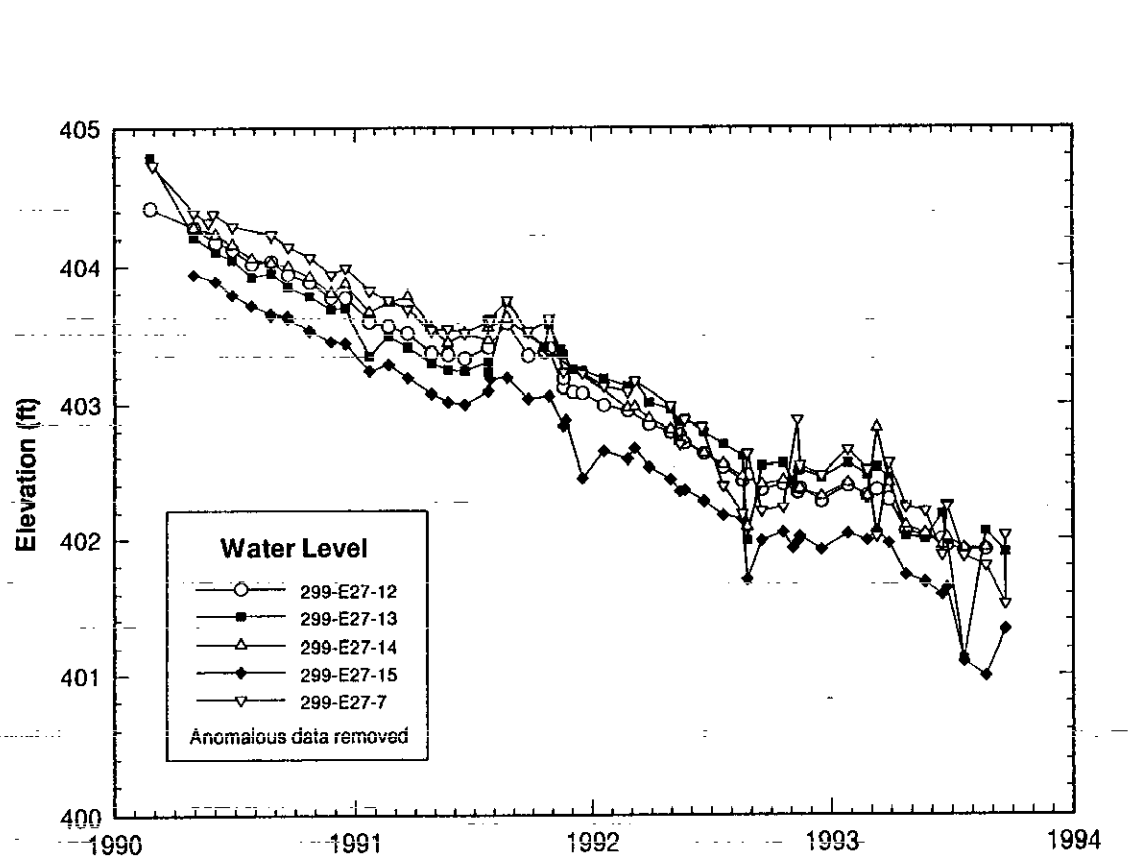


Figure 4.13-8. 200 East Area Hydrograph for Single-Shell Tank Waste Management Areas A-AX, B-BX-BY, and C.

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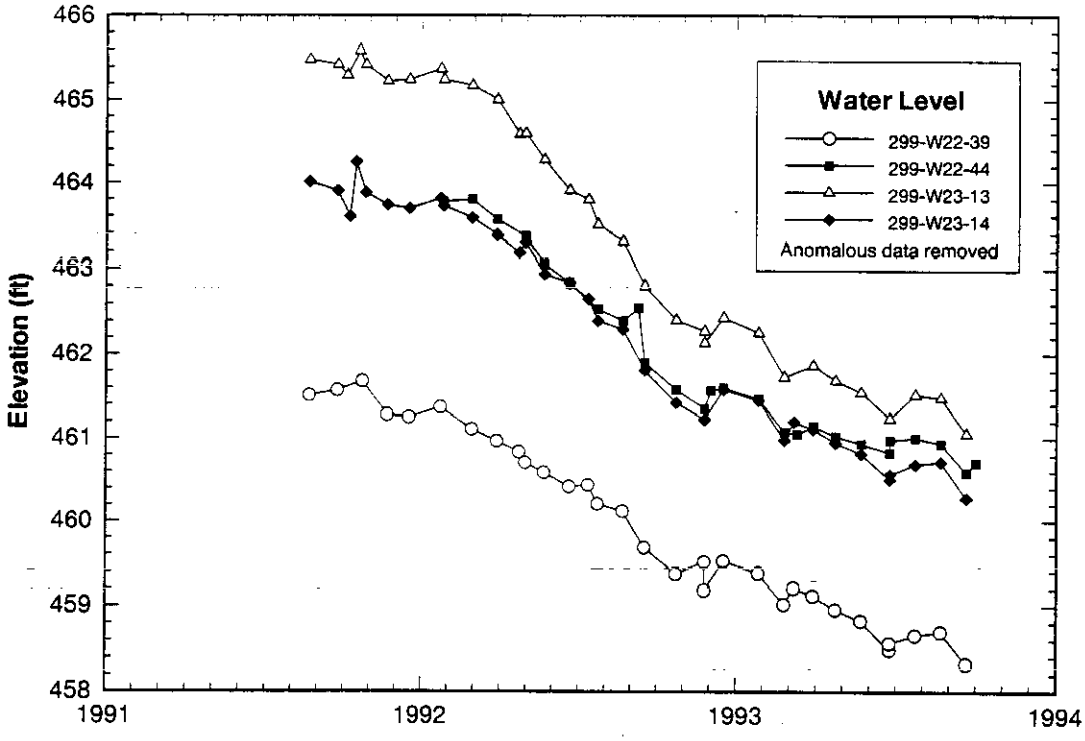
Figure 4.13-9. 200 West Area Hydrographs for Single-Shell Tank Waste Management Areas S-SX and T.



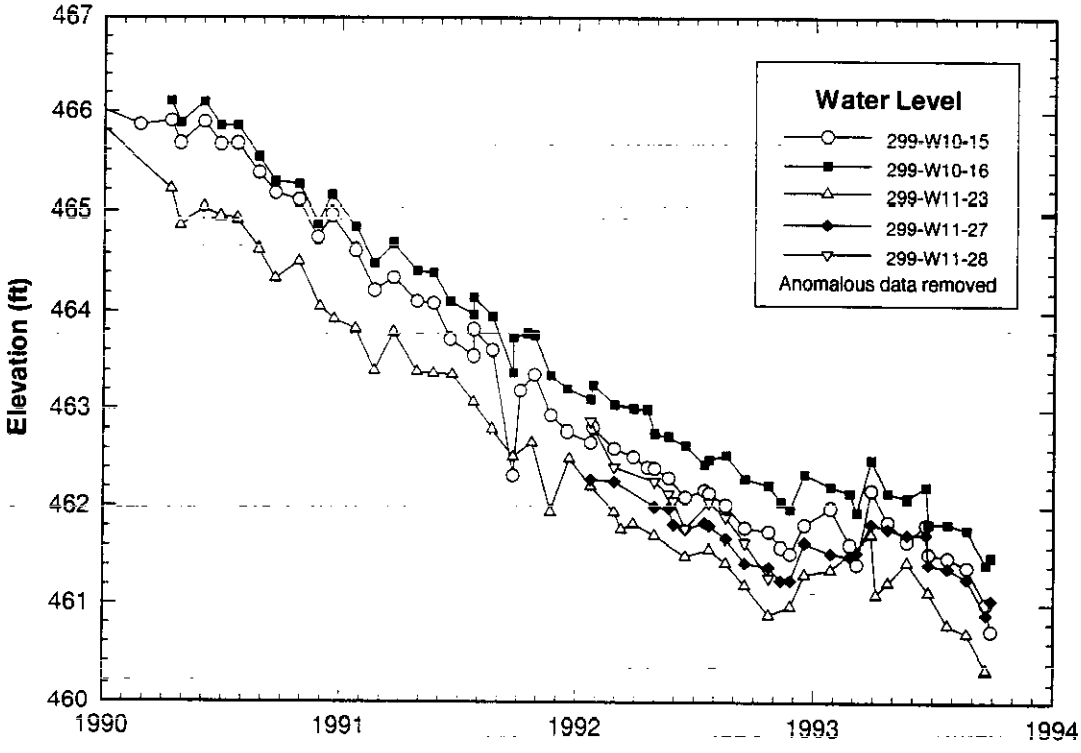
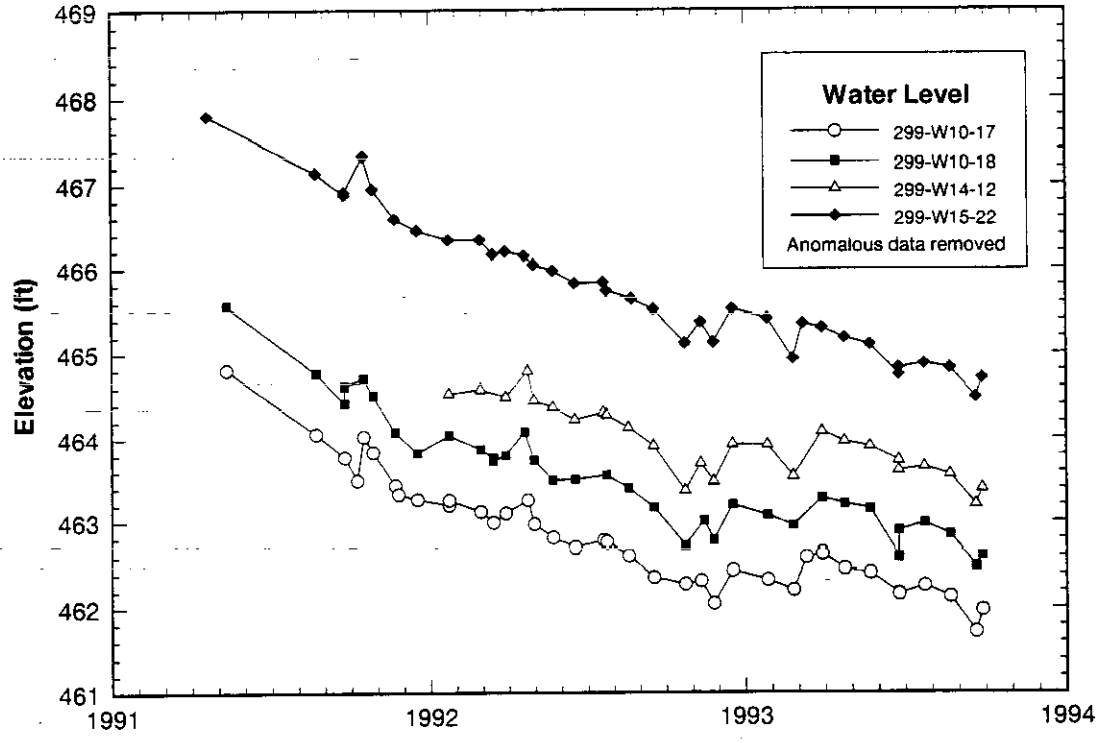
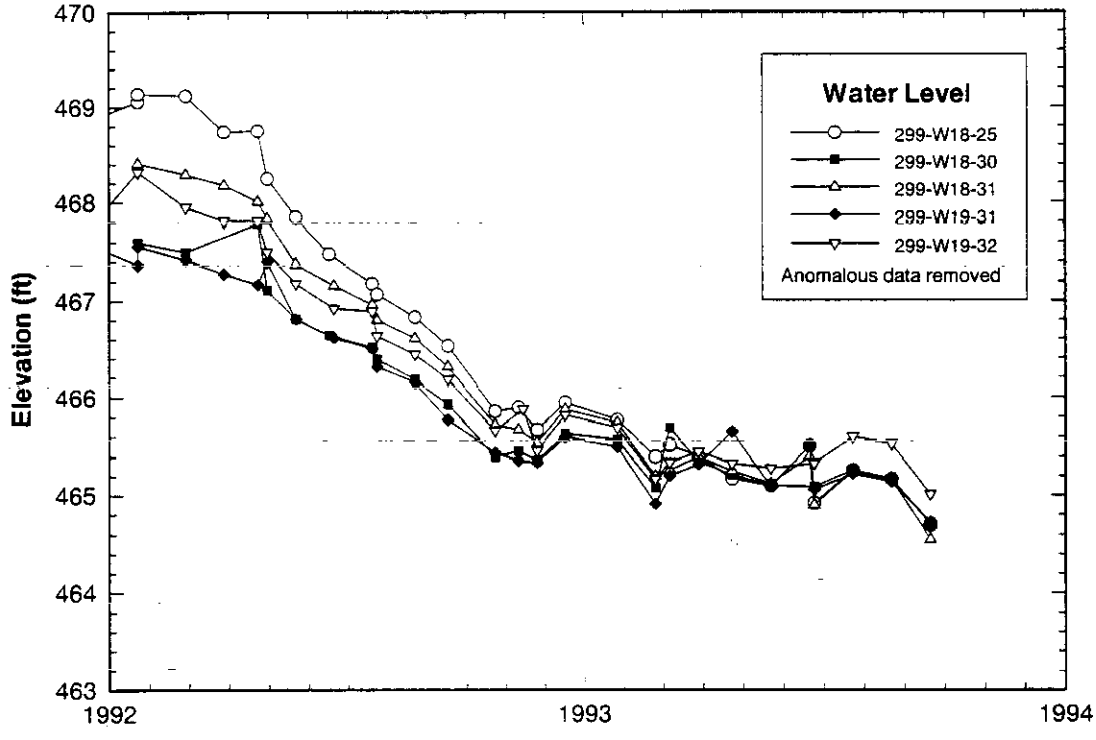


Figure 4.13-10. 200 West Area Hydrographs for Single-Shell Tank Waste Management Areas TX-TY and U.





Groundwater flow across WMA A-AX is generally from the east toward the west-southwest. The hydraulic gradient calculated from June 1993 data is about 0.0003. Groundwater flow across WMA C is generally toward the west. The hydraulic gradient calculated from June 1993 water level data is about 0.0005. Groundwater flow across WMA B-BX-BY is generally toward the west to northwest to north. True direction of groundwater flow in this area of very low gradient in the northern part of the 200 East Area is difficult to determine accurately. The hydraulic gradient calculated from June 1993 water level data is about 0.00006.

4.13.4.1.2 200 West Area Groundwater Flow Direction. For WMAs in the 200 West Area, the controlling influence on the direction of groundwater flow is the regional west to east gradient as well as a groundwater mound, which developed beneath the former 216-U-10 Pond (hereafter referred to as the U Pond mound, see Figure 4.13-7). The U Pond received liquid effluents from 1944 to 1984 when the pond was decommissioned. Since 1984, the U Pond mound has been declining and the crest of the groundwater mound has been shifting eastward as a result of decay of the mound as well as shifting loci of wastewater discharge (Serkowski and Jordan 1989; Kasza 1990; Newcomer 1990; Kasza et al. 1992). Because of lower transmissivity of the middle member of the Ringold Formation (the principal stratigraphic unit of the unconfined aquifer in the 200 West Area), the U Pond mound was higher and resulted in a steeper radially outward gradient than the B Pond mound in the 200 East Area. The U Pond mound also created a significant vertical groundwater flow gradient in the 200 West Area. Smaller groundwater mounds may have developed beneath some cribs that received high volumes of liquid effluents in the early days of Hanford Site operations, but the data are not adequate to decipher any such small features. It is known that water levels around WMA U (in older carbon steel-constructed wells 2-W19-1 and 2-W19-12) have fluctuated by about 2.4 m (8 ft) from the late 1950's to 1984 when U Pond was decommissioned. Water level in these two wells has declined more than 3.6 m (12 ft) since 1984.

In the southern part of the 200 West Area, the direction of groundwater flow beneath WMA S-SX is to the southeast. With the decline and eastward shift of the U Pond mound, the groundwater will assume a more southerly direction of flow before eventually returning to the pre-Hanford Site direction of west to east flow. The hydraulic gradient calculated from June 1993 water level data is about 0.0020.

The direction of groundwater flow beneath WMA T in the northern part of the 200 West Area is north to northeast. The gradient calculated from June 1993 water level data is 0.00035, a significant reduction from the 0.001 gradient calculated for 1992. With the projected decline in the U Pond mound in the next several years, groundwater flow is anticipated to return to the original pre-Hanford Site west to east flow direction and the vertical component of gradient is expected to decrease beneath this WMA.

The direction of groundwater flow beneath WMA TX-TY is to the north-northeast, similar to WMA T immediately to the north. The hydraulic gradient calculated from June 1993 water level data is 0.0017. With the anticipated further decline of the U Pond mound, the direction of groundwater flow is expected to gradually shift to the regional west to east flow.

The direction of groundwater flow beneath WMA U in the southern part of the 200 West Area is to the east-northeast. However, water level in planned downgradient well 2-W19-32 has been higher than in planned upgradient well 2-W18-25 by up to 9 cm (0.3 ft) beginning in late spring 1993. This change may be ephemeral because of high-volume discharges to the 216-U-14 Ditch, which trends generally south-southwest and runs approximately parallel to the east fence line of the 241-U Tank Farm. The high discharges were associated with the final run and cleanout campaign of the U Plant. The hydraulic gradient calculated from June 1993 water level data is about 0.0004. Flow direction is controlled by the declining U Pond mound.

As seen from Table 4.13-11, groundwater levels beneath the 200 Areas are on a slow steady decline. The amount of decline of water level varies with wells and the location of the well. With the closure of chemical processing facilities at the Hanford Site, the volume of liquid effluents is expected to decrease; thus, artificial recharge also will decrease. Reduction of liquid discharges is expected to result in a continued decline of water levels in SST groundwater monitoring wells.

4.13.4.1.3 Rate of Groundwater Flow. The groundwater gradient beneath the 200 West Area is steeper and better defined than that beneath the 200 East Area where there is little more than a 30-cm (1-ft) difference in the elevation of the water table between the eastern and western parts of the area (compare Figure 4.13-6 with Figure 4.13-7). Water table gradients are given in Table 4.13-12. The water table beneath the 200 East Area represents a broad hydraulic low area between westward-flowing water from the B Pond mound and the regional eastward gradient (i.e., eastward flow from the 200 West Area, see Figure 2-4).

Groundwater flow velocities were calculated using equation (1) and are given in Table 4.13-13. Hydraulic conductivities were calculated from analysis of single-well slug test data which Connelly et al. (1992b) found to be generally an order of magnitude lower than hydraulic conductivities calculated from constant discharge tests. Data from aquifer tests using constant discharge methods are not available for any SST wells; therefore, slug test data were used. Calculations used effective porosities of 10 and 20%.

$$v = \frac{Ki}{n} \qquad (1)$$

where:

v = Groundwater velocity
K = Hydraulic conductivity
i = Hydraulic gradient
n = Effective porosity.

4.13.4.2 Evaluation of Monitoring Well Network. Based on water levels measured in 1992 and 1993 and on interpreted direction of groundwater flow, the monitoring well networks for WMA A-AX, B-BX-BY, C, S-SX, T, and TX-TY appear to comply with the requirement for placement of groundwater monitoring

Table 4.13-12. Hydraulic Gradients at Single-Shell Tank Waste Management Areas.

WMA	Well no.	Date water levels measured	Diff. in head (ft)[a]	Gradient
A-AX	E25-2, E24-19 E25-40, E24-19	6/24/93 6/24/93	0.31 0.21	0.0005 0.0002
B-BX-BY	E33-33, E33-24 E33-33, E33-32	6/23/93 6/23/93	0.28 0.09	0.0001 0.00005
C	E27-14, E27-15 E27-7, E27-12	6/23/93 6/23/93	0.37 0.20	0.0007 0.0004
S-SX	W23-13, W23-2 W23-14, W22-46	6/24/93 6/24/93	1.47 2.28	0.0015 0.0025
T	W10-16, W11-27 W10-16, W10-9	6/24/93 6/24/93	0.41 0.17	0.0005 0.0002
TX-TY	W15-22, W10-17 W15-22, W10-18	6/24/93 6/24/93	2.66 1.93	0.0017 0.0017
U[b]	W18-25, W19-32 W18-31, W18-30	6/24/93 6/24/93	0.41 0.15	0.00066 0.00008

[a]Measurements are made in feet and fractions thereof and are therefore reported in those units. To convert feet to meters, divide by 3.28.

[b]The direction of groundwater flow beneath WMA U in June 1993 was reversed from what it has been, i.e., water levels in planned upgradient wells 2-W18-25 and 2-W18-31 were declining faster than in planned downgradient wells 2-W19-32 and 2-W18-30. This reversal began in late spring and may be temporary because of short-term high-volume discharges during late spring to the 216-U-14 Ditch, which is located east of the 241-U Tank Farm. These discharges were related to the final campaign and cleanout of the 221-U Plant. The changes may also be related to the migration of the apex of the groundwater mound eastward beneath the 241-U Tank Farm or to the possible southwestward expansion of a groundwater mound that may be developing beneath the 284-W Powerhouse Pond. Water levels are being monitored carefully and additional wells monitoring the top of the unconfined aquifer in the vicinity of the 241-U Tank Farm have been added to the water level network to provide more data on this apparent change in groundwater flow direction.

Table 4.13-13. Groundwater Flow Velocities[a,b,c] Unconfined Aquifer Beneath Single-Shell Tank Waste Management Areas.

WMA	Well no.	Hydraulic conductivity (m/d [ft/d])	Hydraulic gradient[d]	Effective porosity	Flow velocity (m/d [ft/d])
A-AX	E24-19	33.5 (110)	0.00035	0.20	0.06 (0.19)
		33.5 (110)	0.00035	0.10	0.12 (0.38)
	E25-40	21.3 (70)	0.00035	0.20	0.04 (0.12)
		21.3 (70)	0.00035	0.10	0.08 (0.25)
	E25-41	7.3 (24)	0.00035	0.20	0.01 (0.04)
		7.3 (24)	0.00035	0.10	0.02 (0.08)
B-BX-BY	E33-33	97.5 (320)	0.000075	0.20	0.04 (0.12)
		97.5 (320)	0.000075	0.10	0.07 (0.24)
C	E27-13	54.8 (180)	0.00055	0.20	0.15 (0.50)
		54.8 (180)	0.00055	0.10	0.3 (1.0)
	E27-14	48.7 (160)	0.00055	0.20	0.13 (0.44)
		48.7 (160)	0.00055	0.10	0.27 (0.88)
	E27-15	119 (390)	0.00055	0.20	0.34 (1.1)
		119 (390)	0.00055	0.10	0.64 (2.1)
S-SX	W23-13	27.4 (90)	0.002	0.20	0.27 (0.9)
		27.4 (90)	0.002	0.10	0.55 (1.8)
	W23-14	0.43 (1.4)	0.002	0.20	0.003 (0.01)
		0.43 (1.4)	0.002	0.10	0.009 (0.03)
T	W10-15	10.1 (33)	0.00035	0.20	0.02 (0.06)
		10.1 (33)	0.00035	0.10	0.04 (0.12)
	W10-16	10.1 (33)	0.00035	0.20	0.02 (0.06)
		10.1 (33)	0.00035	0.10	0.04 (0.12)
TX-TY	W15-22	15.2 (50)	0.0017	0.20	0.13 (0.43)
		15.2 (50)	0.0017	0.10	0.26 (0.85)
	W10-18	54.8 (180)	0.0017	0.20	0.46 (1.5)
		54.8 (180)	0.0017	0.10	0.94 (3.1)
U	W18-25	6.1 (20)	0.00037	0.20	0.01 (0.04)
		6.1 (20)	0.00037	0.10	0.02 (0.07)
	W19-31	36.6 (120)	0.00037	0.20	0.07 (0.22)
		36.6 (120)	0.00037	0.10	0.13 (0.44)

[a]Calculated using: $v = Ki/n$, where K = hydraulic conductivity, i = gradient, and n = effective porosity.

[b]Hydraulic conductivities were calculated from results of slug tests performed in wells indicated (Newcomer et al. 1990). Connelly et al. (1992b) found that hydraulic conductivities determined from slug tests may be an order of magnitude too low compared with hydraulic conductivities calculated from constant discharge tests.

[c]All of these wells are completed as 4-in. wells with stainless steel screens (0.10 or 0.20 slot) in the uppermost part of the unconfined aquifer beneath each site. Most 200 East Area wells are completed in the Hanford formation; most 200 West Area wells are completed in the Ringold Formation.

[d]Average of two values for hydraulic gradient given in Table 4.13-12.

wells. The wells constructed as upgradient appear to be upgradient; wells constructed as downgradient appear to be downgradient. The only possible exception occurs at WMA U where the water level in planned downgradient well 2-W19-32 is not declining as fast as in planned upgradient wells 2-W18-25 and 2-W18-31, and now exceeds the water level in planned upgradient wells by up to 9 cm (0.3 ft). If this condition persists, an additional downgradient well will be needed at WMA U.

Older carbon steel wells are present in all WMAs and serve as screening wells for measurement of water levels. Thus, the control of groundwater flow direction is better than that afforded by the minimal four RCRA standard well network.

The Monitoring Efficiency Model (MEMO) was run for all WMAs to maximize efficiency of the monitoring network and to expedite new well locations. The goal in locating wells is to achieve 90% efficiency of the network using MEMO (Wilson et al. 1992). Efficiencies were calculated for all WMAs and they are close to or exceed the target efficiency. Detailed results of the MEMO calculations may be found in the revised groundwater monitoring plan for the SSTs (Caggiano and Goodwin 1991).

4.13.4.3 Monitoring Network Modifications. Gradients are very low in the 200 East Area. Continued observation will be required as discharges to B Pond diminish and the B Pond mound dissipates to ensure that wells are properly placed so as to be upgradient or downgradient from WMAs. With a change in flow direction anticipated as long term, additional wells will be needed in the 200 East Area. As water levels continue to decline, groundwater monitoring wells may have to be replaced or remediated when the wells no longer penetrate the saturated zone of the uppermost unconfined aquifer. Pump intakes have had to be lowered in several wells in 1993 to accommodate declining water levels. No changes to the network because of changing groundwater flow direction or water levels are required at this time.

With dissipation of the U Pond mound, groundwater flow in the 200 West Area will shift to a more easterly flow. As this long-term change occurs, additional wells may be required to ensure that wells for the various WMAs in the 200 West Area are located appropriately upgradient and downgradient and that the wells penetrate the saturated section of the uppermost unconfined aquifer. No changes to the networks in the 200 West Area are needed at this time, but water levels will continue to be monitored around WMA U to see whether the change in groundwater flow direction observed in 1993 is ephemeral or permanent. If permanent, an additional well will be required at WMA U.

4.13.5 References

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5.0 600 AREA

F. N. Hodges
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5.1 HYDROGEOLOGY OF THE 600 AREA

The 600 Area is essentially a "catchall" for everything not included in other operational areas of the Hanford Site. This section discusses the portion of the 600 Area southeast of the 200 East Area (Figure 5.1-1), henceforth referred to as the "600 Area." This portion of the 600 Area contains the old Central Landfill Complex that is made up of the Solid Waste Landfill and the Nonradioactive Dangerous Waste Landfill.

5.1.1 Geology of the 600 Area

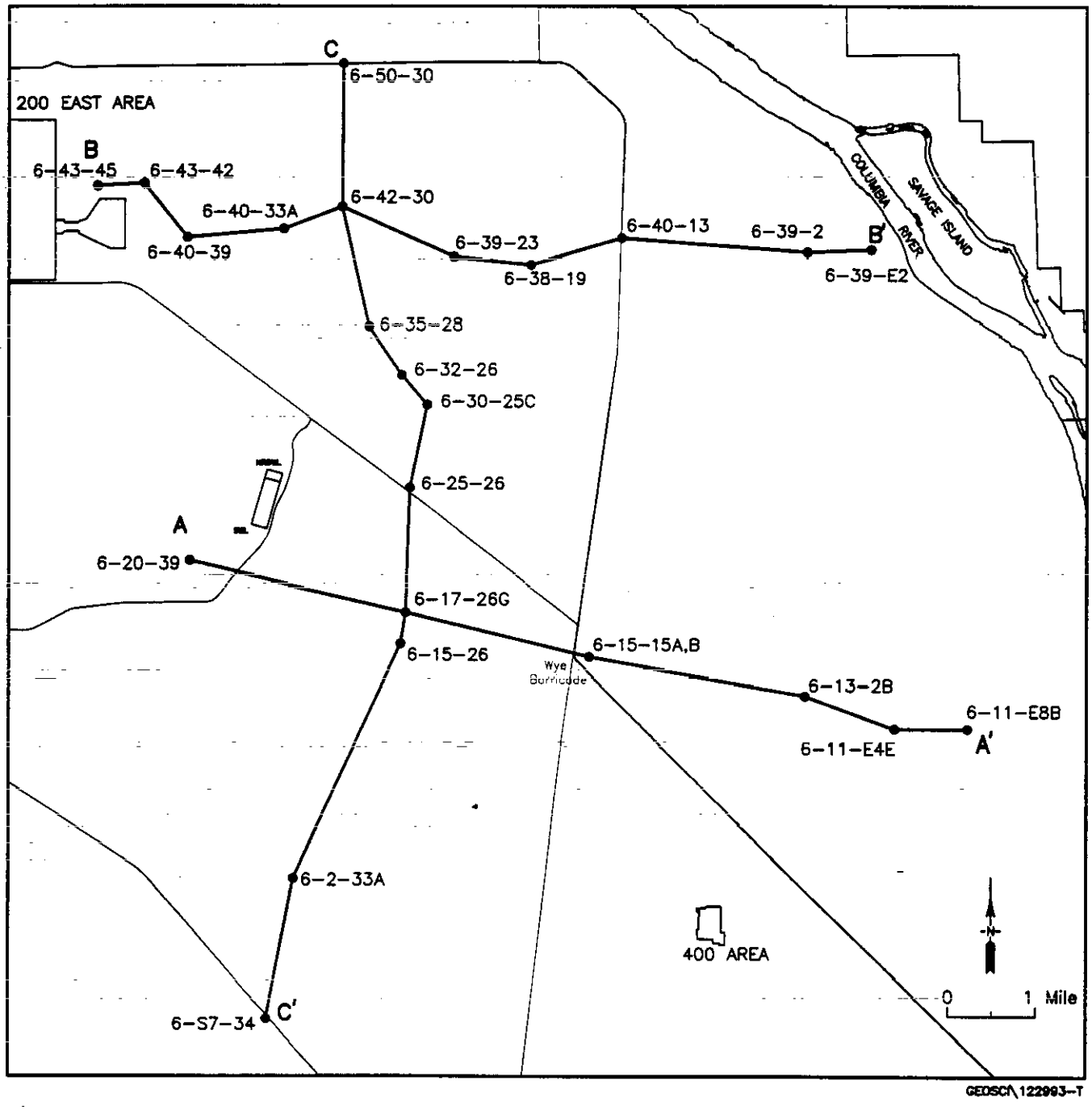
The geology of the 600 Area is described in Delaney et al. (1991). Details of the geology in the vicinity of the Central Landfill Complex are available in Weekes et al. (1987) and Fruland et al. (1989).

The geology of the area southeast the 200 East Area is dominated by the broad southeastward plunging synclinal basin between Gable Mountain and Rattlesnake Mountain (see Figure 2-2), the deepest part of which is formed by the Cold Creek syncline (see Section 2.1.5). The synclinal basin is filled with Miocene to Pleistocene sediments, principally Ringold Formation and Hanford formation, that reach a combined thickness of greater than 215 m (700 ft) along the axis of the Cold Creek syncline. Holocene sediments, principally aeolian deposits, form a thin veneer across the area.

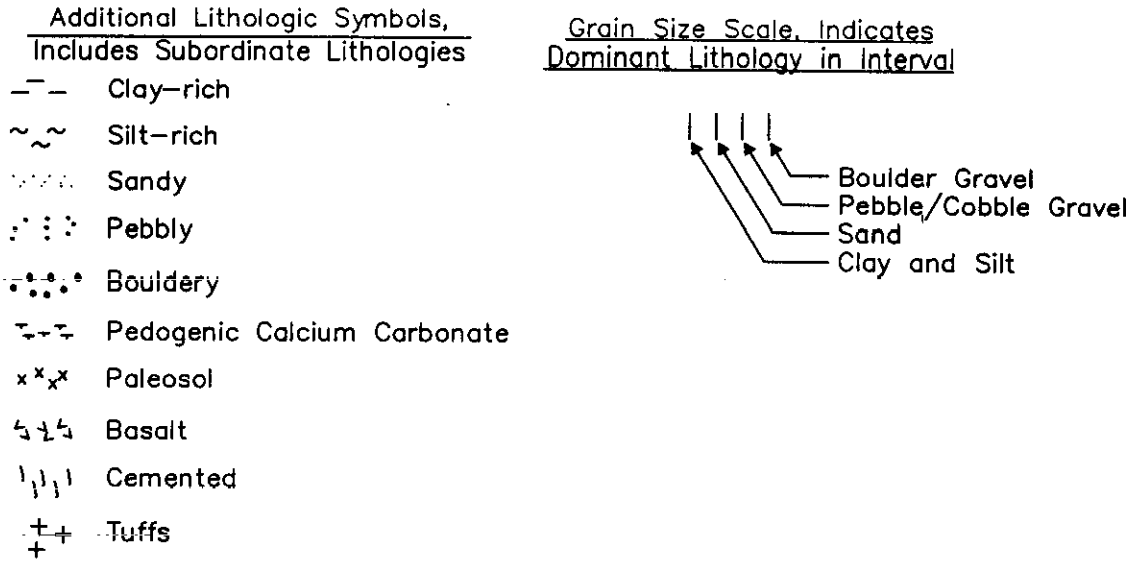
The stratigraphy of the 600 Area is presented in three cross sections (Figures 5.1-2, 5.1-3, and 5.1-4). Locations of the cross sections are shown in Figure 5.1-1. Figures 5.1-2 and 5.1-3 are east-west cross sections that extend across the area from near the 200 East Area to the Columbia River. Figure 5.1-2 parallels the axis of the Cold Creek syncline and shows that the entire Ringold Sequence is present in the area (see Section 2.1.1, Figure 2-1). However, only a remnant of the upper Ringold is present, the remainder having been removed by erosion. The cross section in Figure 5.1-3 indicates the presence of the May Junction Fault and the thinning of the Ringold Formation in the 200 East Area. The May Junction Fault is a north-south trending fault that cuts the Ringold Sequence. It is uncertain whether or not it affects Hanford formation sediments. The Ringold units thin into the 200 East Area where they are truncated, and in some areas, completely removed by erosion. The upturned, truncated Ringold units, directly overlain by Hanford formation sediments, are potentially down-dip conduits for dense contaminants, either dense nonaqueous phase liquids (DNAPL) or dense aqueous phase brines, to enter the Ringold aquifer.

Figure 5.1-4, a north-south cross section, illustrates several important features: (1) the synclinal basin between Gable Mountain and Rattlesnake Mountain, with the Cold Creek Syncline and several smaller folds; (2) the

Figure 5.1-1. Map of 600 Area Showing Locations of Cross Sections Presented in Figures 5.1-2, 5.1-3, and 5.1-4.



Explanation



Abbreviations

PM – Pre–Missoula gravels
PP – Plio–Pleistocene/early Palouse interval
UR – Upper unit, Ringold Formation
E – Unit E, Ringold Formation
C – Unit C, Ringold Formation
D – Unit D, Ringold Formation
B – Unit B, Ringold Formation
LM – lower Mud unit, Ringold Formation
A – unit A, Ringold Formation

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Figure 5.1-2. Geologic Cross Section Along Line A-A' in Figure 5.1-1 (Geology by Kevin Lindsey, Westinghouse Geosciences).

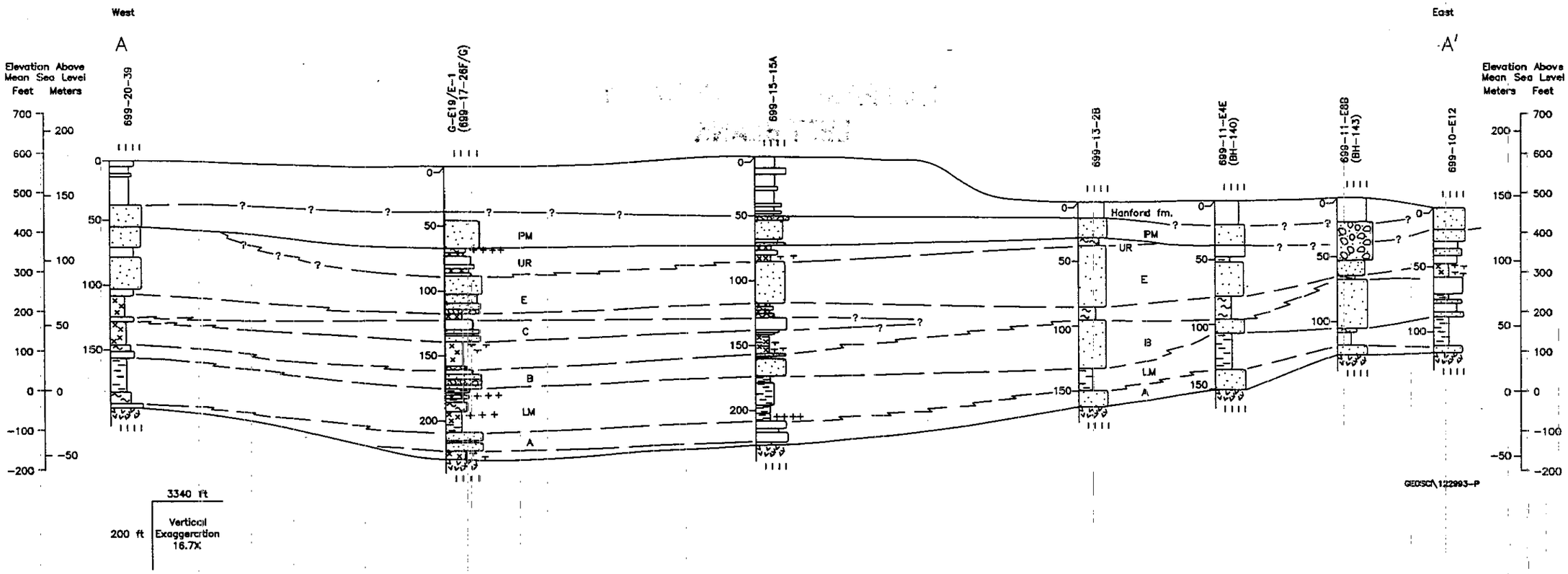

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Figure 5.1-3 Geologic Cross Section Along Line B-B' in Figure 5.1-1 (Geology by Kevin Lindsey, Westinghouse Geosciences).

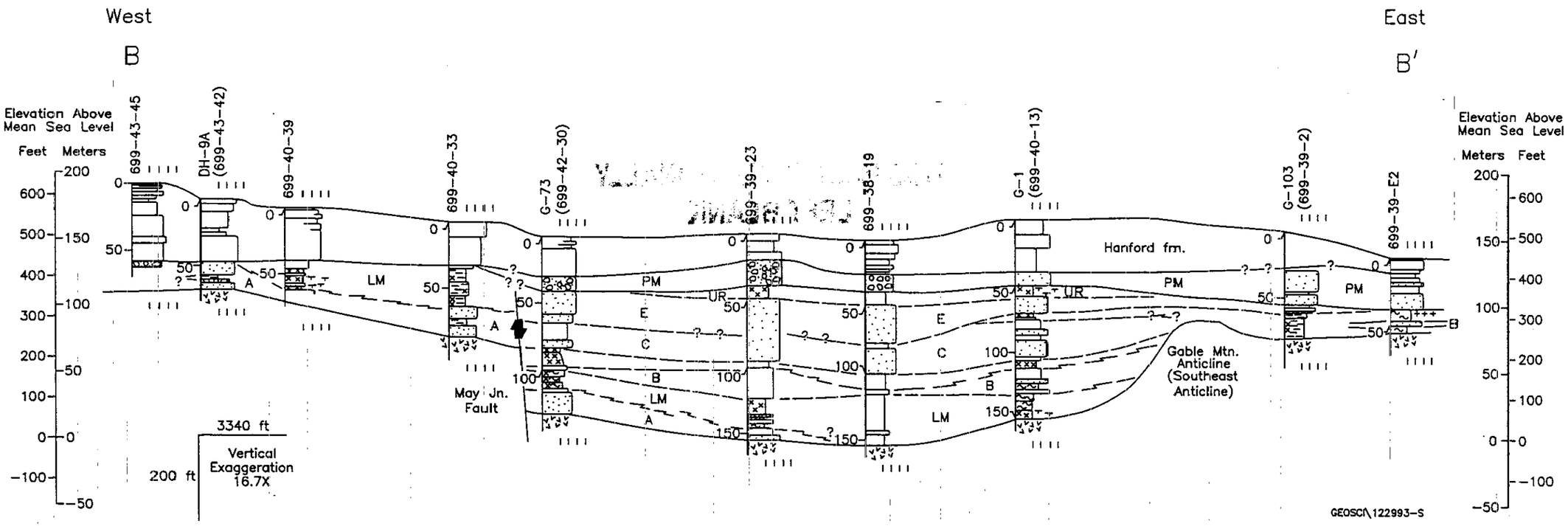

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Figure 5.1-4. Geologic Cross Section Along Line C-C' in Figure 5.1-1 (Geology by Kevin Lindsey, Westinghouse Geosciences).

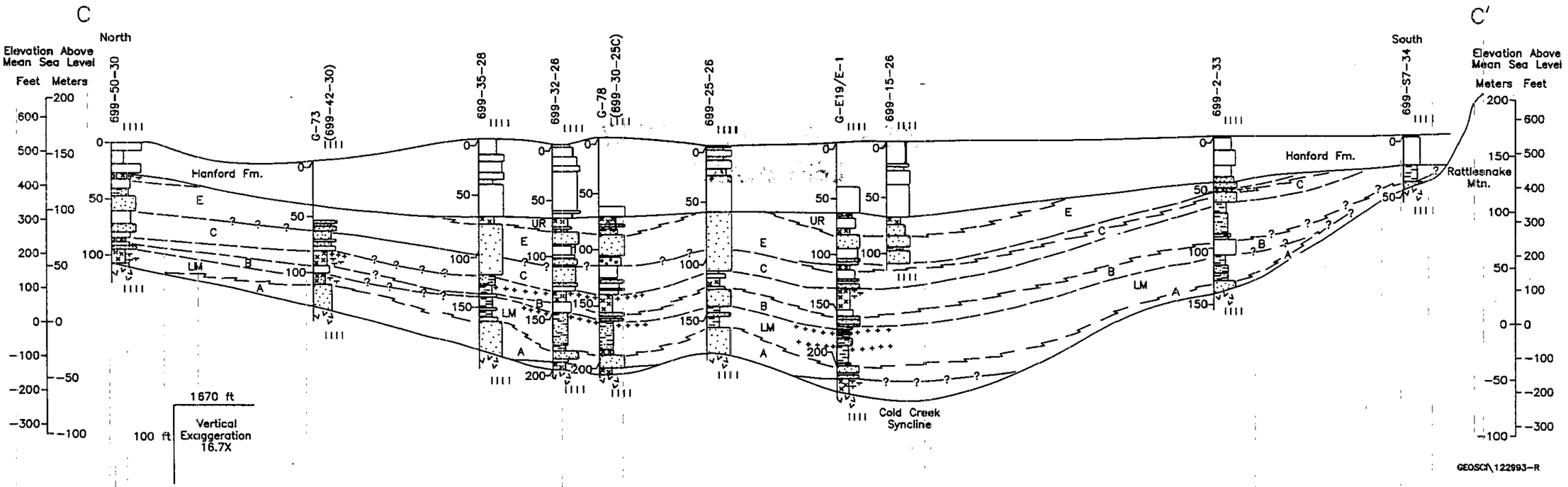

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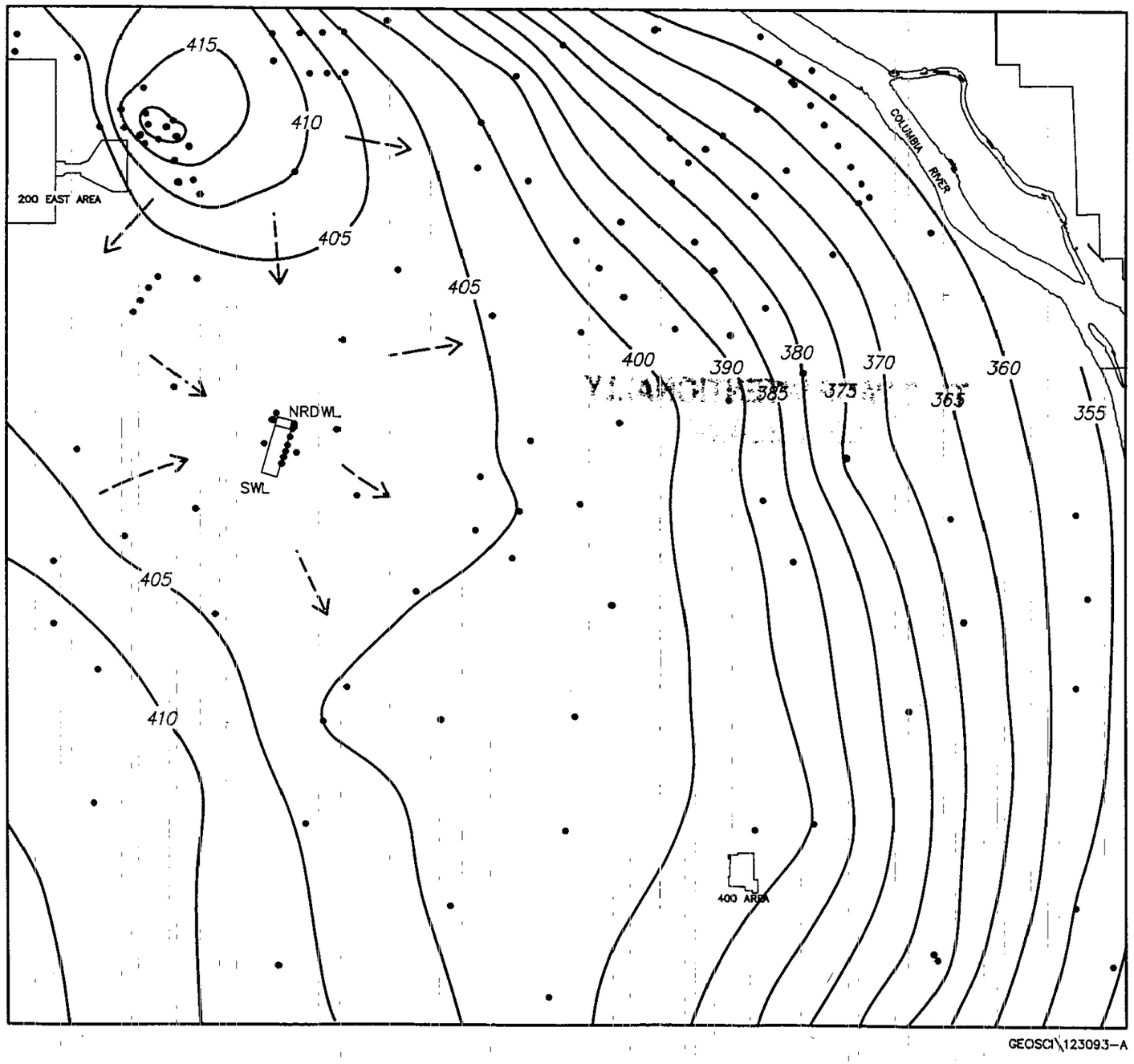
Figure 5.1-5. 600 Area Water Table Map, June 1993 (Contour Values are Feet Above Mean Sea Level).



Legend

- Groundwater Monitoring Well Location
- 405 — Water Table Contour, Feet Above Mean Sea Level
- Generalized Flow Direction
- NRDWL Nonradioactive Dangerous Waste Landfill
- SWL Solid Waste Landfill

0 1 Mile 2 Mile

0 1000 2000 3000 Feet

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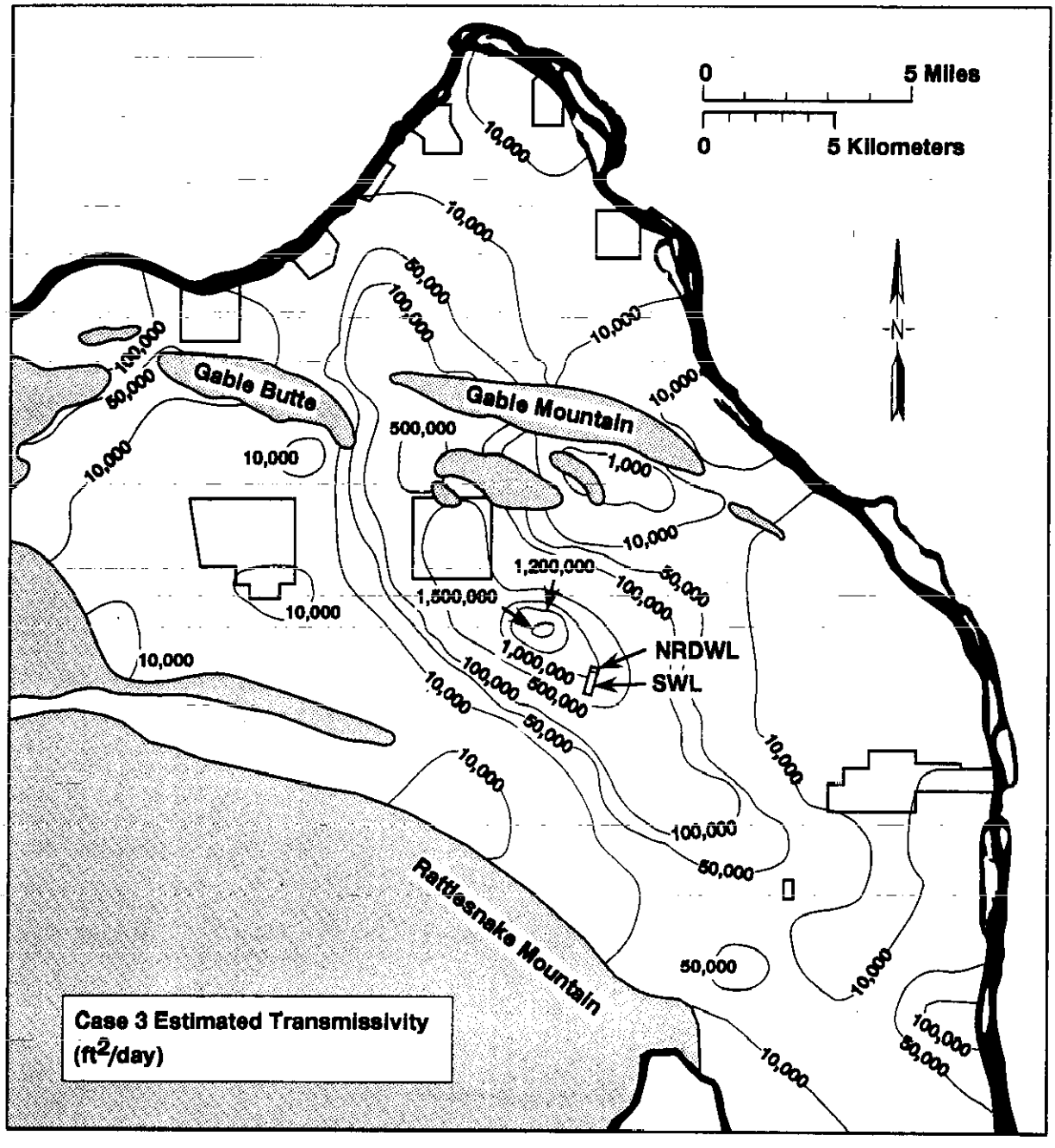
Figure 5.1-6. Map Showing Distribution of Estimated Values for Hydraulic Transmissivity in the Hanford Formation Aquifer (Jacobson and Freshley 1990) (Contour Values are ft^2/day).



groundwater elevation changes within the area (Jacobson and Freshley 1990). This feature is significant because it allows high groundwater flow rates, low hydraulic gradients, and apparently controls the transport of contaminants out of the 200 East Area (see Section 5.1.4). Groundwater flow rates along the portion of this zone immediately southeast of the 200 East Area are on the order of 6 m/d (20 ft/d), based upon tritium plume transport rates.

B Pond, which receives on the order of 1 billion L/yr (2.6 million gal/yr) of effluent from the 200 East Area, acts as a major driving force for groundwater flow. Radial flow outward from B Pond also mobilizes contaminants beneath the 200 East Area and controls, to some extent, the location of contaminant plumes within the zone of high transmissivity.

Groundwater flow within the deeper suprabasalt aquifer is largely uncharted. There is little reason to believe that the general flow is not from west to east, from the areas of recharge toward the Columbia River; however, the potential effects of recharge in the 200 East Area are unknown. Groundwater flow within the Rattlesnake interbed, the uppermost sedimentary layer within the basalt sequence in this area, is from west to east (Dresel et al. 1993).

5.1.4 Groundwater Chemistry in the 600 Area

The groundwater chemistry of the uppermost aquifer within the 600 Area is controlled principally by three factors. The first factor is flow of essentially uncontaminated groundwater into the area from the west. Second is the introduction of large quantities of Columbia River water through various effluent streams (i.e., B Pond). The third factor is the introduction of contaminants, principally tritium and nitrate, from the southeastern portion of the 200 East Area.

The groundwater flowing into the area from recharge areas to the west (Cold Creek and Dry Creek Valleys) is a relatively dilute calcium bicarbonate water resulting from evaporation of meteoric waters and interaction (rock-water reaction) with aquifer materials. An estimate of this "background" groundwater composition is provided in Johnson (1993).

Columbia River water, used widely on the Hanford Site for cooling and other purposes, has much lower dissolved solids than unaltered Hanford Site groundwater. Its major effect is to dilute existing groundwater in the area.

The major contaminants in the Hanford formation aquifer in the 600 Area are tritium and nitrate, originating in the 200 East Area. The configuration of the tritium plume is shown in Figure 5.1-7; the nitrate plume configuration is shown in Figure 5.1-8. Note the correspondence between the contaminant plumes and the zone of high transmissivity shown in Figure 5.1-6. After passing the Central Landfill Complex the contaminant plumes tend to spread and to separate into north and south lobes. Minor plumes of nonsorbing radionuclides such as ^{129}I are also present (see Figure 2-8).

Chemistry within the Ringold portion of the suprabasalt aquifer is very poorly known. Very few chemical data exist for this portion of the aquifer; however, Eddy et al. (1978) reported tritium contamination near the bottom of

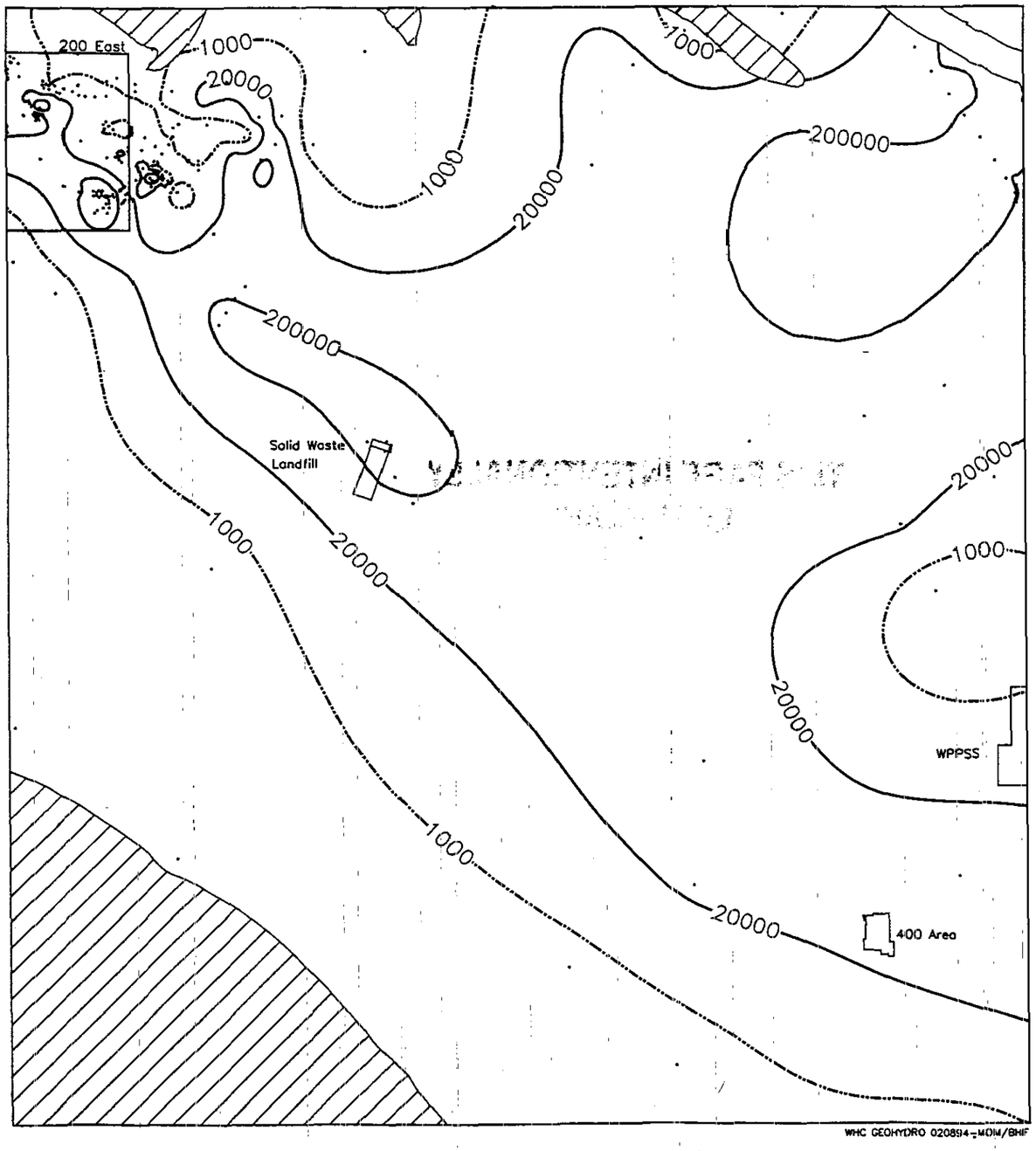


Figure 5.1-7. Plume Map Showing Distribution of Tritium in the 600 Area (Based on 1993 Data).

Hanford Site

Tritium

Groundwater Plume Map

• Well Location

1000 Concentration Isopleth

This map was constructed from average values for the period 1/1/91–10/1/93, with anomalous data points removed.

Detection Limit. . . . . .500 pCi/L
Drinking Water Standard. . . . . 20,000 pCi/L
Washington Water Quality Standard. . . 20,000 pCi/L
1/25 Derived Concentration Guide. . . . 80,000 pCi/L
Maximum Concentration Limit. . . . . 20,000 pCi/L

0 1000 2000 3000
METERS

0 5000 10000
FEET

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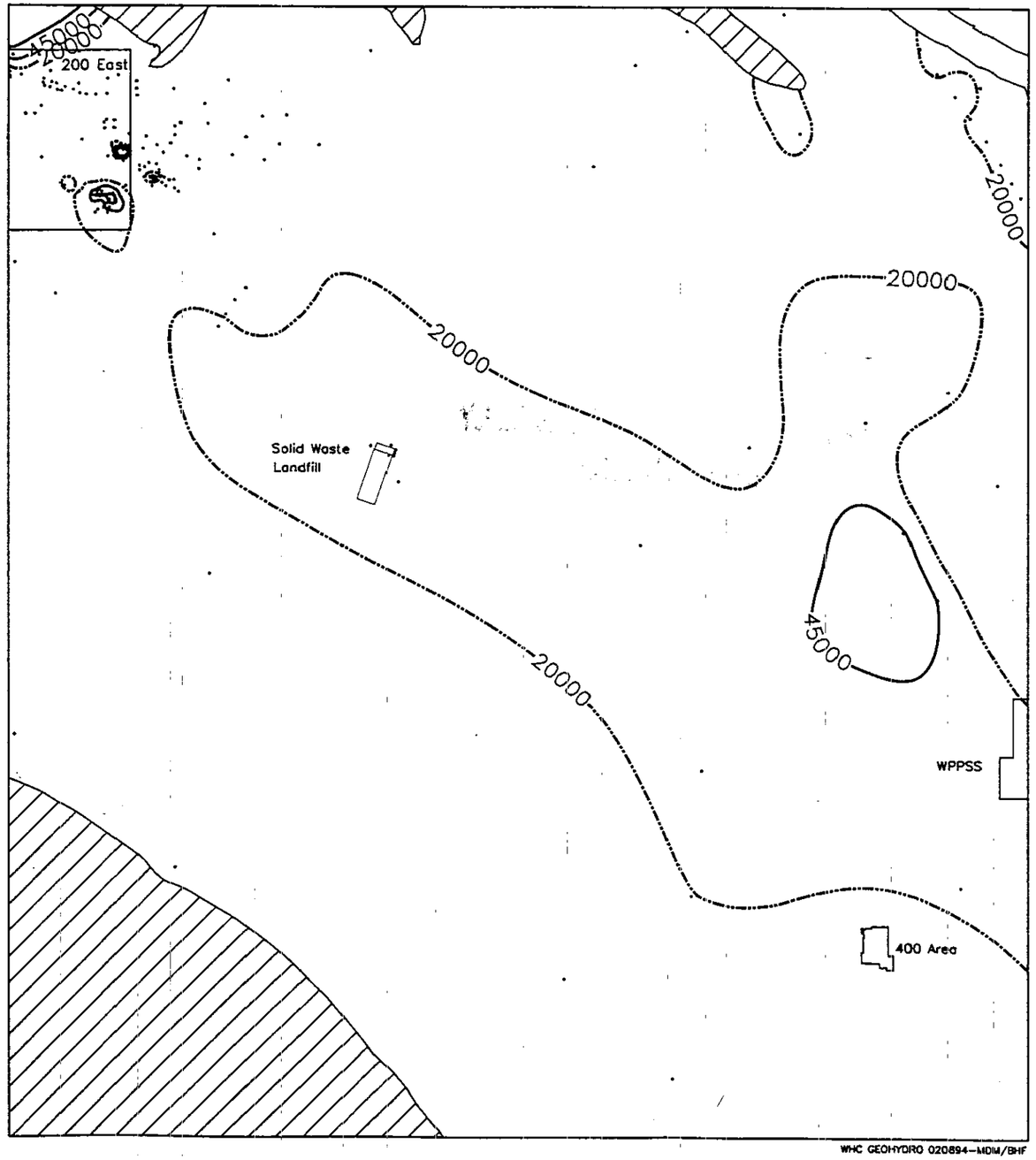
Figure 5.1-8. Plume Map Showing Distribution of Nitrate in the 600 Area (Based on 1993 Data).



Hanford Site

Nitrate

Groundwater Plume Map

• Well Location

20,000 Concentration Isopleth

This map was constructed from average values for the period 1/1/91–10/1/93, with anomalous data points removed.

Detection Limit	.500 ppb
Drinking Water Standard	45,000 ppb
Washington Water Quality Standard	45,000 ppb
1/25 Derived Concentration Guide	N/A
Maximum Concentration Limit	N/A

0 1000 2000 3000
METERS

0 5000 10000
FEET

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the Ringold Formation in well 699-31-31, located approximately 2 km (1.3 mi) northwest of the Central Landfill Complex.

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The Nonradioactive Dangerous Waste Landfill (NRDWL) is a 4-ha (10-acre) inactive dangerous waste landfill located approximately 5.5 km (3.5 mi) southeast of the 200 East Area (see Figure 1-1, Chapter 1.0).

5.2.1 Facility Overview

The NRDWL, part of the Central Landfill Complex, which also includes the adjacent Solid Waste Landfill (SWL), received dangerous nonradioactive waste from 1975 to 1985. The NRDWL continued to receive asbestos waste until 1988 (DOE-RL 1990). It was agreed, as part of the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1992), to close the NRDWL under the appropriate Washington State dangerous waste regulations. The NRDWL is part of operable unit 200-IU-3, which also includes the adjacent SWL. A closure/postclosure plan was submitted to the Washington State Department of Ecology (Ecology) in 1990 (DOE-RL 1990). Groundwater monitoring at the NRDWL is controlled by the NRDWL groundwater monitoring plan (WHC 1993b).

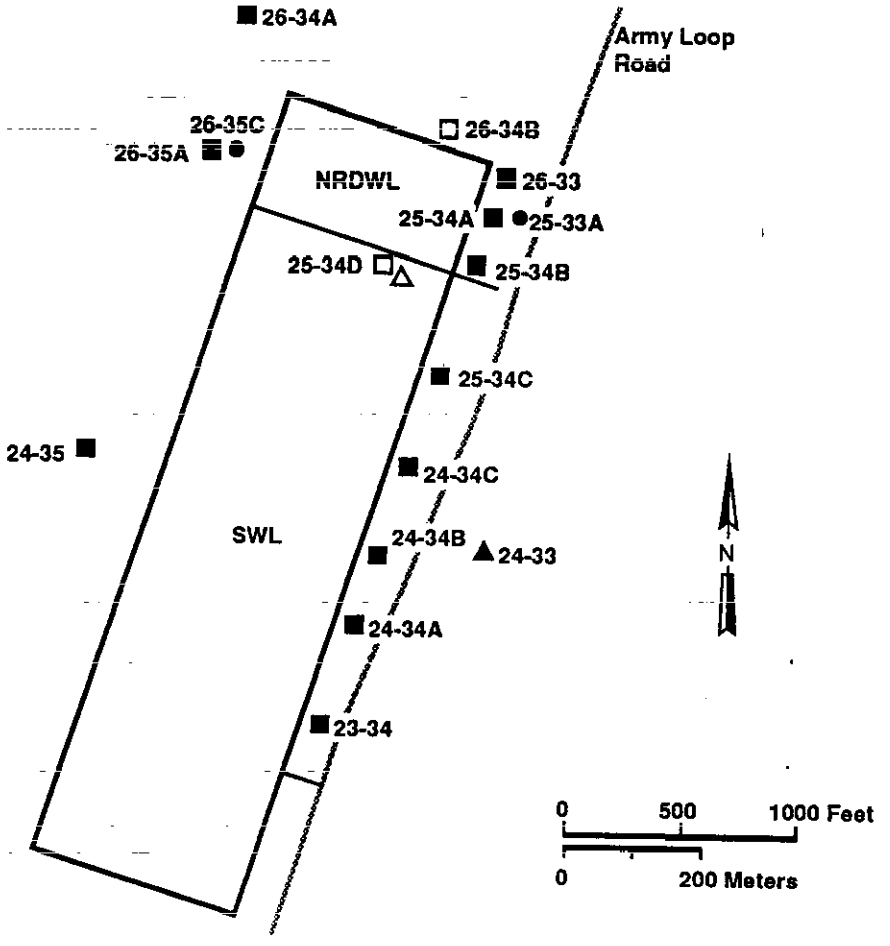
An indicator evaluation groundwater monitoring program was initiated at the NRDWL in late 1986 and early 1987 under interim-status regulations (40 CFR 265, Subpart F) as a result of an Ecology compliance order (Ecology and EPA 1986). Site characterization and establishment of the groundwater monitoring program are described in Weekes et al. (1987). Quarterly sampling at the NRDWL was concluded in the fourth quarter of 1989 and the initial monitoring network is currently on a semiannual sampling schedule. Two new monitoring wells completed in October 1992 (WHC 1993a) are currently on a quarterly sampling schedule that will end in December 1993. The groundwater monitoring network for the NRDWL is shown in Figure 5.2-1.

The NRDWL lies above approximately 180 m (600 ft) of suprabasalt aquifer within the Ringold and Hanford Formations. The Hanford formation beneath the site consists of sands and gravels, with sands predominant near the surface and gravels dominating the deeper portions of the formation. Thin, discontinuous silt layers as well as clastic dikes are common in the upper part of the formation (Weekes et al. 1987). The water table occurs at a depth of approximately 38 m (125 ft) and approximately 18 m (60 ft) of Hanford formation is saturated. The deepest well at the NRDWL penetrated to a depth of 78 m (255 ft), bottoming in the top of Ringold Formation unit E. The upper Ringold Formation contains a thin, clay silt-rich layer that may be locally confining (Weekes et al. 1987). The general stratigraphy of the sediments beneath the landfill is presented in Figure 5.2-2.

5.2.2 Summary of 1993 RCRA Activities

Scheduled semiannual sampling of the monitoring network was carried out in March and September 1993. Well 699-25-34B, not sampled in March 1993 as the result of a scheduling error, was sampled in April 1993. In addition, wells 699-25-34D and 699-26-34B were sampled in December 1992 and June 1993.

Figure 5.2-1. Map of the Nonradioactive Dangerous Waste Landfill and Solid Waste Landfill Showing the Locations of Groundwater Monitoring Wells.



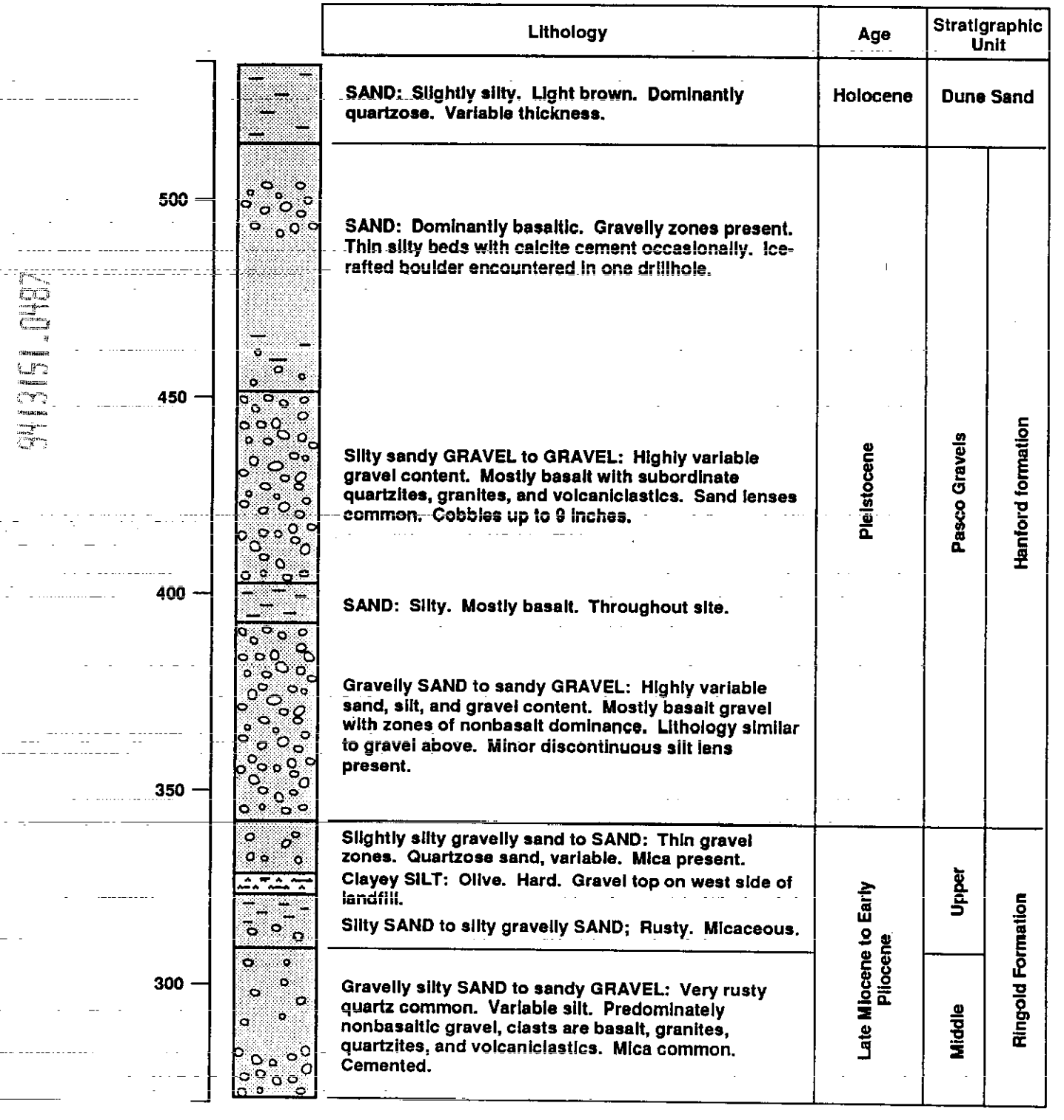
△ Proposed '94 Deep Well
■ Well completed at the top of the unconfined aquifer
● Well completed in the upper Ringold Formation
▲ Well not constructed to RCRA specifications
□ New RCRA wells completed in 1992.

NRDWL Nonradioactive Dangerous Waste Landfill
SWL Solid Waste Landfill

All wells prefixed by 699-

H9012007.95

Figure 5.2-2. Generalized Stratigraphic Column for the Nonradioactive Dangerous Waste Landfill (Weekes et al. 1987).



H9401033.2

Water levels were determined in all of the monitoring wells during the routine samplings in March, April, and September 1992. Water levels were also measured during the quarterly samplings of wells 699-25-34D and 699-26-34D in December 1992 and June 1993. Regular water level determinations were carried out on a monthly schedule throughout 1993 for the older network and were started in August 1993 for the two new wells.

The 1993 analytical results and water table elevation measurements for the NRDWL groundwater monitoring network are reported in RCRA quarterly reports (DOE-RL 1993a, 1993b, 1993c, 1994).

Two new RCRA monitoring wells at the NRDWL were completed in October 1992 (WHC 1993a) and were sampled for the first time in December 1992. The new wells are completed at the top of the saturated zone and complete the shallow downgradient network for the site. The two new wells were completed with 10.7-m (35-ft) screened intervals. The longer screens were emplaced to allow for the drop in water table elevation that will result from the shutdown of effluent discharge in the 200 Areas.

5.2.3 Other Activities in 1993

A geophysical survey of the NRDWL was carried out using ground-penetrating radar and electromagnetic induction techniques (Mitchell et al. 1993). The results indicate considerably more irregularity in trench boundaries than indicated in existing documentation. Several of the trenches appear to merge laterally and four trenches merge with the J. A. Jones trench in the adjacent SWL. In addition, the soil cover over waste seems to be less than reported, in many areas thinning to as little as 0.6 m (2 ft).

A shallow vadose zone soil gas survey was carried out at the NRDWL and immediately adjacent portions of the SWL (Jacques and Kerkow 1993). The study consisted of an initial survey with field screening instruments, followed up with a more detailed study using gas chromatography. The results of the survey indicate the widespread occurrence of acetone and several chlorinated hydrocarbons in the shallow vadose zone at the site.

The chlorinated hydrocarbons with the widest distribution in the shallow vadose zone are trichloroethene (TCE) and tetrachloroethene (PCE), with PCE being the most persistent and occurring at the highest concentrations. Other chlorinated hydrocarbons that are more local in occurrence include 1,1,1-trichloroethane (111-TCA), carbon tetrachloride, and chloroform. The highest concentrations of chlorinated hydrocarbons occur over the older chemical trenches near the east end of the landfill.

5.2.4 Sampling and Analysis Program

The monitoring network at the NRDWL consists of nine wells, seven completed in late 1986 and early 1987, and two completed in 1992 (see Figure 5.2-1; WHC 1993a). There are three upgradient wells. Two of the upgradient wells (699-26-35A and 699-26-34A) are completed in the top of the saturated zone, at a depth of approximately 45 m (145 ft), in the Hanford formation. One upgradient well (699-26-35C) is completed at the top of a low

permeability unit in the upper Ringold Formation, approximately 21 m (70 ft) beneath the water table. There are six downgradient wells. Five of the downgradient wells (699-26-33, 699-26-34B, 699-25-34A, 699-25-34B, and 699-25-34D) are completed in the top of the saturated zone, at a depth of approximately 45 m (145 ft), in the Hanford formation. One downgradient well (699-25-33A) is completed at the top of a low permeability unit in the upper Ringold Formation, approximately 21 m (70 ft) beneath the water table. Monitoring well descriptions are provided in Table 5.2-1.

The NRDWL monitoring network, with the exception of the two new wells, is on a semiannual sampling schedule as required by 40 CFR 265. The constituent list (Table 5.2-2) for analysis consists of the contamination indicator parameters, the interim primary drinking water standards, and the groundwater quality parameters. In addition, the list of analyses includes volatile halogenated hydrocarbons and tritium. Halogenated hydrocarbons were added to the constituent list both because of their presence at the adjacent SWL (Section 5.3.5) and because of their potential as contaminants from waste in the NRDWL. Tritium was added to the constituent list in 1989 as an aid in determining groundwater flow directions and flow rates at the site. The tritium and nitrate in groundwater at the NRDWL has a source in the 200 Areas.

5.2.5 Groundwater Chemistry

The following discussion concentrates on the contamination indicator parameters, tritium, nitrate, and chlorinated hydrocarbons. The indicator parameters are required by *Resource Conservation and Recovery Act of 1976* (RCRA) regulations; nitrate and tritium, which have an upgradient source, because of their potential role as groundwater tracers; and chlorinated hydrocarbons because they may represent, to some extent, groundwater contamination originating from the NRDWL.

In the following discussion it should be noted that starting with the June 1993 sampling the analytical laboratory is reporting concentrations between the method detection limit and the contractually required quantitation limit (CRQL). Previously all values below the CRQL were reported as nondetects.

5.2.5.1 Constituents of Concern. Field pH values in shallow downgradient wells ranged from 7.3 to 7.9, with the lowest values occurring consistently in downgradient well 699-25-34B. Values in the shallow upgradient wells ranged from 7.5 to 7.7. pH values in the two deeper wells were virtually indistinguishable, ranging from 7.8 to 8.1.

Field conductance values for the shallow downgradient wells ranged from 414 to 501 μmho/cm. Values for the upgradient wells ranged from 349 to 433 μmho/cm. Values for the deep upgradient well ranged from 356 to 397 μmho/cm and for the deep downgradient well from 287 to 309 μmho/cm.

Concentrations for total organic carbon (TOC) reported during the first part of the year were all reported as less than the CRQL of 1,000 ppb. Reported concentrations for data from the later part of the year range from 200 to 700 ppb. The 700-ppb value was reported with a laboratory qualifier,

Table 5.2-1. Monitoring Wells Used for the Nonradioactive Dangerous Waste Landfill.

Well	Aquifer	Sampling frequency	Water levels	Well standard	Other networks
699-26-33[86]	Top of unconfined	SA	M	RCRA	--
699-26-34A[86b]	Top of unconfined	SA	M	RCRA	--
699-26-34B[92]	Top of unconfined	Q	M	RCRA	--
699-26-35A[86]	Top of unconfined	SA	M	RCRA	SWL
699-26-35C[87]	Top of LPU[a]	SA	M	RCRA	--
699-25-33A[87]	Top of LPU[a]	SA	M	RCRA	--
699-25-34A[86]	Top of unconfined	SA	M	RCRA	--
699-25-34B[86]	Top of unconfined	SA	M	RCRA	--
699-25-34D[92]	Top of unconfined	Q	M	RCRA	--

Notes: Shading denotes upgradient wells. Superscript number following well number denotes the year of installation.
[a]Low permeability unit in the upper Ringold Formation.
[b]Well previously named 699-26-34.
LPU = low permeability unit.
M = sampled or measured on a monthly basis.
Q = sampled or measured on a quarterly basis.
RCRA = well is constructed to RCRA-specified standards.
SA = sampled or measured on a semiannual basis.
SWL = Solid Waste Landfill.

Table 5.2-2. Constituent List for the Nonradioactive Dangerous Waste Landfill.

Contamination indicator parameters		
pH	Total organic carbon	
Specific conductance	Total organic halogen	
Groundwater quality parameters		
Chloride	Manganese	Sodium
Iron	Phenols	Sulfate
Drinking water parameters		
2,4-D	Endrin	Methoxychlor
2,4,5-TP Silvex	Fluoride	Nitrate
Arsenic	Gross alpha	Radium
Barium	Gross beta	Selenium
Cadmium	Lead	Silver
Chromium	Lindane	Toxaphene
Coliform bacteria	Mercury	Turbidity
Site-specific parameters		
Tritium	Volatile chlorinated hydrocarbons	

indicating blank contamination. Unfortunately data for the September sampling of five wells was not received from the laboratory in time for inclusion in this report.

Data for total organic halogen (TOX) from this period have not been evaluated because of ongoing problems with data quality. A discussion of the TOX data is contained in Appendix A.

Nitrate and tritium in the groundwater beneath the NRDWL are elevated as a result of plumes originating in the 200 East Area and moving to the southeast beneath the NRDWL (see Section 5.1). Nitrate values in the shallow monitoring wells, from October 1992 to September 1993, ranged from 25,000 to 30,000 ppb. Nitrate values in deep upgradient well 699-26-35C ranged from 21,000 to 22,000 ppb; nitrate values in deep downgradient well 699-25-33A ranged from 3,700 to 4,000 ppb. Groundwater nitrate concentrations have gone through two maxima since 1987 and currently are declining (Figure 5.2-3).

From August 1991 to September 1992, tritium values in shallow monitoring wells ranged from 189,000 to 271,000 pCi/L. Tritium concentrations in deep upgradient well 699-26-35C ranged from 41,500 to 43,500 pCi/L; deep downgradient well 699-25-33A concentrations ranged from <234 to 283 pCi/L. These tritium concentrations, with the exception of values from deep downgradient well 699-25-33A, exceed the primary groundwater standard of 20,000 pCi/L. The peak of a tritium pulse apparently has passed beneath the site (see Section 5.3.6) and tritium concentrations currently are declining (Figure 5.2-4).

Four chlorinated hydrocarbons have been detected in groundwater at the NRDWL during the period from October 1992 through June 1993. These are 111-TCA (0.8 to 2.7 ppb), TCE (0.1 to 0.6 ppb), PCE (0.1 to 1.1 ppb), and carbon tetrachloride (0.3 to 0.5 ppb). The first three are believed to be present in groundwater at the NRDWL principally as a result of vadose zone vapor transport from the adjacent SWL; however, a contribution from the NRDWL cannot be ruled out. The fourth, carbon tetrachloride, may be a result of vadose zone contamination at the NRDWL. Analytical data for volatile halogenated hydrocarbons from the September 1993 sampling are unavailable for this report. Distributions of chlorinated hydrocarbon concentrations along the compliance point boundaries of the NRDWL and SWL are presented in Section 5.3.6.

5.2.5.2 Statistical Evaluation. Statistical evaluations of data for this year at the NRDWL consisted of the required comparisons between upgradient and downgradient wells for any indication of contamination in the groundwater underlying the facility. Statistical methods are described in Appendix C. Statistical analyses required by 40 CFR 265.93(b) and WAC 173-303-400 were performed on background samples collected from November 1987 to July 1988; the results are presented in Table 5.2-3. This table lists the background average, background standard deviation, and critical mean (or critical range, in the case of pH) for the four contamination indicator parameters from the upgradient wells. The critical mean (or critical range) is the value to which current and future averages of quadruplicate measurements are compared. For the NRDWL, the calculated critical range for pH is so large that it is meaningless. An alternative range for upgradient/downgradient comparisons was calculated by using upgradient data collected from November 1987 to June 1992.

Figure 5.2-3. Time Series Plot of Nitrate Concentrations (ppb) in Shallow Monitoring Wells at the NRDWL.

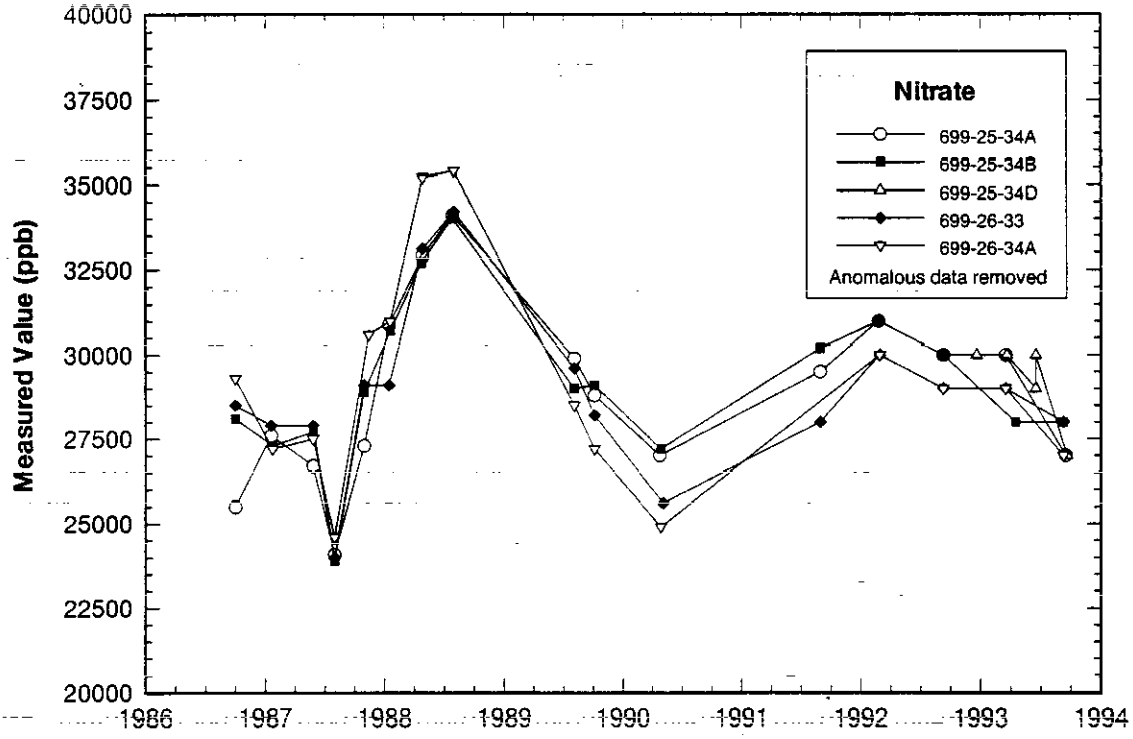


Figure 5.2-4. Time Series Plot of Tritium Concentrations (pCi/L) in Shallow Monitoring Wells at the NRDWL.

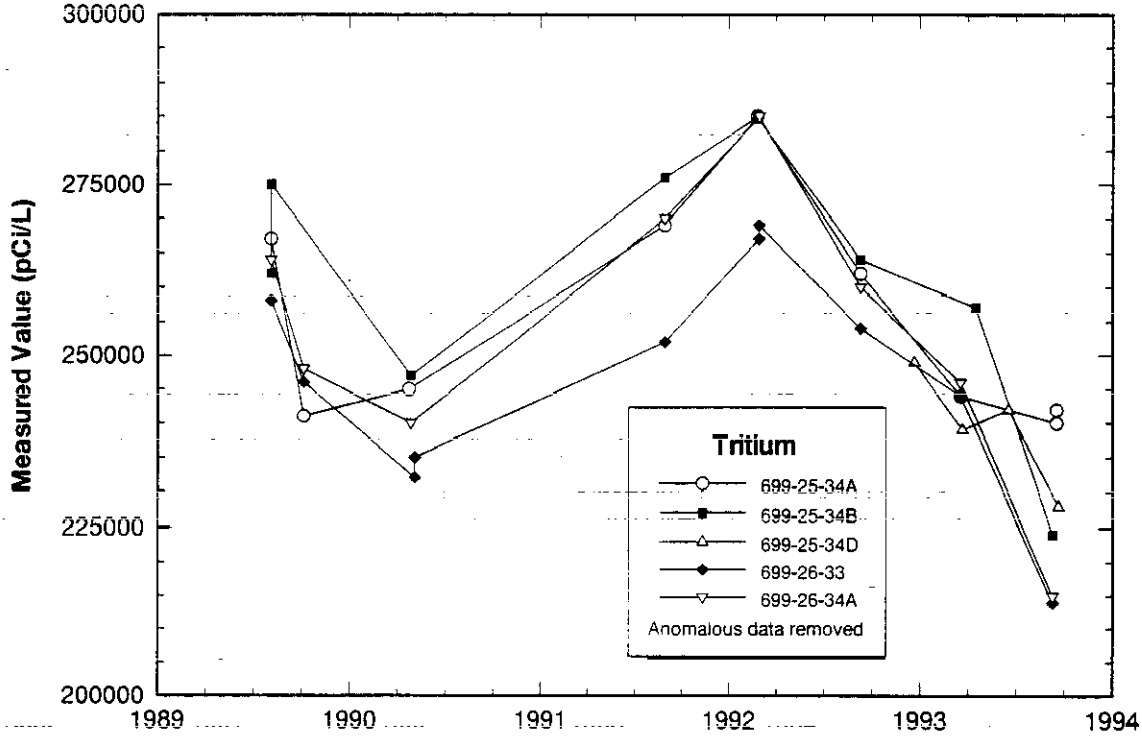


Table 5.2-3. Critical Means Table for 28 Comparisons--Background Contamination Indicator Parameter Data for the Nonradioactive Dangerous Waste Landfill.[a,b]

Constituent (unit)	n	df	t_c	Average background	Standard deviation	Critical mean	Upgradient/ downgradient comparison value
Specific conductance (μmho/cm)	8	7	5.7282	335.31	80.088	821.9	821.9
Field pH	7	6	7.2227	7.546	0.685	[2.26, 12.84]	[5.16, 9.87][d]
Total organic carbon[c] (ppb)	8	7	5.7282	424.65	89.98	971.3	971.3
Total organic halogen[c] (ppb)	8	7	5.7282	5.15	1.83	16.3	NC

[a]Data collected from November 1987 to July 1988 for upgradient wells 6-26-34A and 6-26-35A. Critical means calculated based on 28 comparisons.

[b]The following notations are used in this table:

df = degrees of freedom (n-1)

n = number of background replicate averages

t_c = Bonferroni critical t-value for appropriate df and 28 comparisons.

[c]Critical mean were calculated from values reported below the contractually required quantitation limits.

[d]Upgradient/downgradient comparison values for pH were calculated using data collected from November 1987 to June 1992 (wells 6-26-34A and 6-25-35A) because the critical range calculated using only four quarters of data is too large to be meaningful.

NC = not calculated.

If the average constituent concentration for a downgradient well exceeds the upgradient/downgradient comparison value listed in Table 5.2-3, that parameter is considered statistically different from background. If this is confirmed by subsequent verification sampling and analysis, the regulatory program is triggered into assessment. The critical mean for TOX is presented here for information only. It will not be used for this year's comparisons because of unsatisfactory audit findings (see Appendix A).

The data from the upgradient wells that were used to compute critical means came from a different laboratory than recent data. The comparability of recent indicator parameter data with historical data was evaluated to assess impacts of the change of analytical laboratory and the time gap observed between sampling events (DOE-RL 1992). The recent values of pH and TOC were all comparable to historical data. The TOX data were not compared.

Values for field pH, specific conductance, and TOC were all below the critical mean for the sampling period. TOX data were not evaluated because of laboratory problems.

5.2.6 Groundwater Flow

In addition to water table levels determined at the time of groundwater sampling, regular measurements were made for all wells on a monthly schedule during 1993. The discussions of water table elevations, groundwater flow directions, and groundwater flow velocities are based on the regular monthly measurements. The 1993 water level measurements for the NRDWL monitoring network were reported in RCRA quarterly reports.

The NRDWL lies in a zone of very high hydraulic transmissivity (see Section 5.1) and as a result there is a very low hydraulic gradient across the site. A map of the water table in the vicinity of the site, based on June 1993 data, is presented in Figure 5.2-5. This map illustrates the low hydraulic gradients in the vicinity of the NRDWL.

The water table in the vicinity of the NRDWL has dropped approximately 1.3 m (4 ft) since December 1988, apparently as a result of decreased water input to B Pond. This decrease in water table elevation is illustrated in Figure 5.2-6, which are hydrographs of the monthly water level measurements at NRDWL wells. This plot also illustrates a problem with water level measurements at the NRDWL that has developed over the past year. The reason for the large amount of scatter in the recent water level measurements is unknown, but is under investigation.

5.2.6.1 Groundwater Flow Directions. Hydraulic gradients across the NRDWL are on the order of 0.0001, yielding water level differences across the site that are well within the envelope of surveying and measurement error. In past years it has been possible to make estimates of average groundwater flow directions on the basis of water level measurements; however, the large scatter in groundwater elevation data makes this impossible for 1993 data.

Figure 5.2-5. Water Table Map (Potentiometric Surface) for the Vicinity of the Nonradioactive Dangerous Waste Landfill Based on June 1993 Water Level Measurements. (Datum is Mean Sea Level).

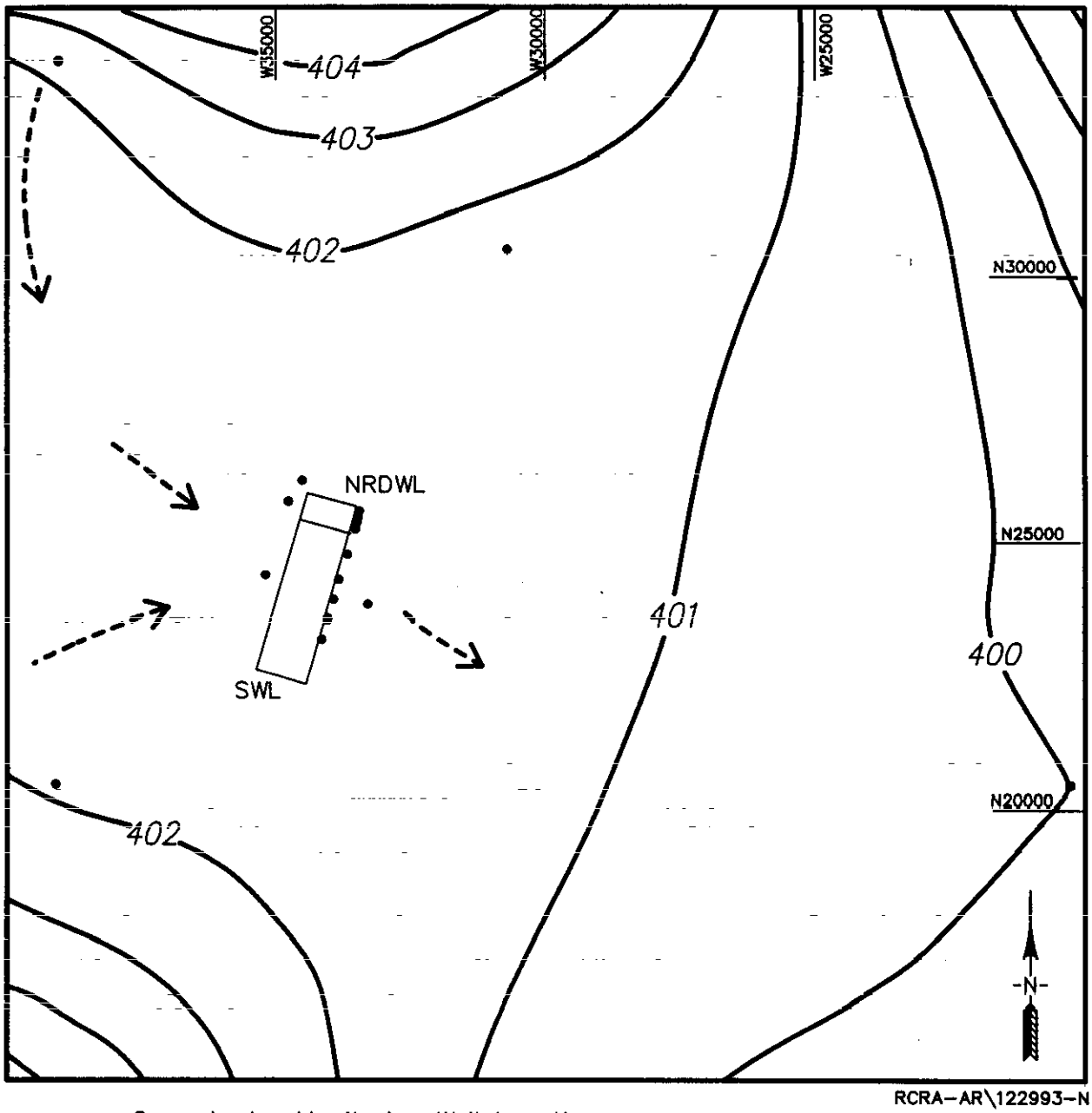
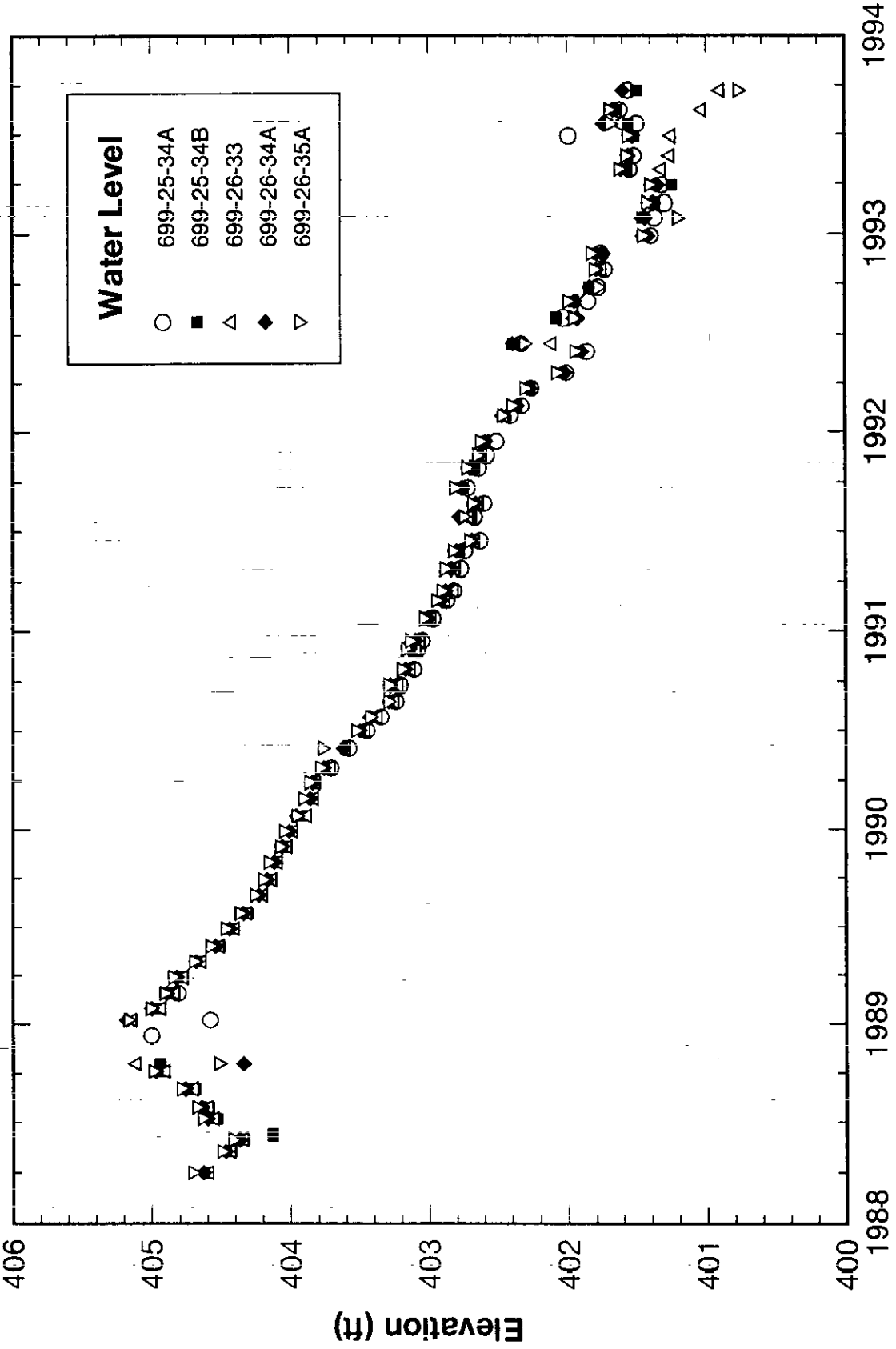


Figure 5.2-6. Hydrographs of Monthly Water Level Measurements (Feet Above Mean Sea Level) at the Nonradioactive Dangerous Waste Landfill.



Groundwater flow directions, previously calculated from regular water level measurements for wells 699-26-35A, 699-36-33, and 699-25-34B have provided relatively consistent average flow direction, 62 ± 10° east of north (DOE-RL 1994), 65 ± 20° east of north (DOE-RL 1991), and 67 to 90° east of north (Weekes et al. 1987). These value are in poor agreement with the groundwater flow direction of approximately 125° east of north indicated by the nitrate and tritium plumes that pass through the area (DOE-RL 1991) and regional water table maps. The difference in flow directions indicated by the two techniques may indicate well survey problems; however, a resurvey by Kaiser Engineers Hanford in 1991 resulted in no significant change in well elevations.

5.2.6.2 Rate of Flow. The rate of groundwater flow beneath the NRDWL is highly uncertain. The aquifer beneath the NRDWL is characterized by high hydraulic transmissivities and conductivities and very low gradients. On the basis of site-specific aquifer testing and the observed hydraulic gradients, the expected groundwater velocities should be on the order of 1.2 to 1.8 m/d (4 to 6 ft/d) (Weekes et al. 1987). However, more direct velocity indicators indicate a range of much higher values.

Transport velocities in the 200 East Area, indicated by contaminant transport within the Hanford formation, indicate groundwater flow velocities from 3 to 4.3 m/d (10 to 14 ft/d) (Wilber et al. 1983). Tracer tests in the area southeast of the 200 East Area indicated groundwater velocities in excess of 30 m/d (100 ft/d); however, they occurred at higher hydraulic gradients than exist today (Bierschenk 1959).

Tracking of the present tritium and nitrate plumes from wells several miles upgradient from well 699-24-33, which is located approximately 150 m (500 ft) east of the SWL, indicates contaminant transport rates in excess of 6 m/d (20 ft/d). In addition, the recent decrease in nitrate and tritium concentrations is indistinguishable in quarterly sampling of upgradient and downgradient wells (see Section 5.3), indicating that the time required for the contaminants to traverse the site is less than 3 months. This traverse time indicates groundwater transport rates greater than 5.5 m/d (18 ft/d). The actual transport rate is probably controlled by zones of very high groundwater velocity within the Hanford formation that are missed or averaged out in normal aquifer testing.

5.2.6.3 Evaluation of Monitoring Well Network. The uncertainty in groundwater flow directions beneath the NRDWL makes evaluation of the monitoring network more difficult. If the groundwater flows in a southeast direction, as indicated by the nitrate and tritium plumes, the boundary between the NRDWL and SWL should be part of the compliance point. If the groundwater flows in a east-northeast direction, as indicated by the water level data, the northern boundary of the site should be part of the compliance point. The two new monitoring wells along the north and south boundaries of the NRDWL solve this problem and provide MEMO model (Jackson et al. 1991) efficiencies between 96 and 99%, depending on groundwater flow directions. The current shallow monitoring network is adequate; however, deep characterization and monitoring, as called for in the NRDWL groundwater monitoring plan (WHC 1993b), is still needed to fully characterize the aquifer beneath the site.

5.2.7 References

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5.3 SOLID WASTE LANDFILL

F. N. Hodges
Westinghouse Hanford Company

The Solid Waste Landfill (SWL) is a disposal facility whose current activities are covered under *Washington Administrative Code* (WAC) 173-304, "Minimum Functional Standards for Solid Waste Handling." The SWL is not a *Resource Conservation and Recovery Act of 1976* (RCRA) site and is included here for completeness. A permit application for operation of the site under WAC 173-304 was submitted to the Benton-Franklin Health Department in 1991 (DOE-RL 1991a). Responsibility for the site has subsequently been assumed by the Washington State Department of Ecology (Ecology) and a revised permit application was submitted to Ecology in 1993 (DOE-RL 1993b).

5.3.1 Facility Overview

The SWL is a 27-ha (66-acre) landfill facility located approximately 5.6 km (3.5 mi) southeast of the 200 East Area (see Figure 1-1, Chapter 1.0). The SWL, along with the adjacent Nonradioactive Dangerous Waste Landfill (NRDWL), are parts of the old Central Landfill Complex; however, the two facilities are now considered separately under different regulations. The SWL has been in operation since 1972 and has received principally solid waste including paper waste, construction debris, asbestos waste, and lunchroom waste. In addition to the solid waste, an estimated 3,800,000 to 5,700,000 L (1 to 1.5 Mgal) of sewage waste were disposed of in trenches along the east and west sides of the landfill between 1975 and 1987, and approximately 380,000 L (100,000 gal) of Hanford Site bus-garage washwater was disposed of in three short trenches along the west side of the site between 1985 and 1987. The present groundwater monitoring program was initiated in 1987 (Fruland et al. 1989). Current groundwater monitoring of the landfill fall under WAC 173-304 and WHC (1993). The geology and hydrology of the area are described in Section 5.1 and Figure 5.2-2.

5.3.2 Summary of 1993 Groundwater Monitoring Activities

Quarterly sampling of the groundwater monitoring network was carried out in December 1992 and March, July, and September 1993. Water level measurements were made in conjunction with the scheduled sampling. In addition, water level measurements were carried out on a monthly basis throughout the year.

5.3.3 Other Activities in 1993

A survey of shallow vadose zone gases at the adjacent NRDWL extended into the northern portion of the SWL (Jacques and Kerkow 1993). This study confirmed the higher concentrations of carbon dioxide (CO_2) in the vadose zone beneath the SWL. In addition, vadose sampling probes for methane were emplaced along the boundaries of the SWL.

5.3.4 Sampling and Analysis Program

The monitoring network at the SWL consists of two upgradient and five downgradient, compliance-point wells (Figure 5.3-1). The monitoring wells are RCRA compliant with stainless steel casings and screens. The wells were completed at depths of approximately 44 m (145 ft) with screened intervals of 4.6 m (15 ft). The screens were set at 3 m (10 ft) below the water table (Fruland et al. 1989). The wells are all equipped with HydroStar[1] pumps.

In addition, NRDWL upgradient well 699-26-35A is being monitored as an upgradient well for the SWL; an older non-RCRA well (699-24-33), located approximately 150 m (500 ft) east of the SWL, is sampled for indication of trends in groundwater chemistry and historical continuity. A description of the SWL monitoring wells is provided in Table 5.3-1.

The SWL is on a quarterly sampling program as required by WAC 173-304. The constituent list for analysis (Table 5.3-2) consists of the constituents and parameters required by WAC 173-304-490, volatile chlorinated hydrocarbons, tritium, and other constituents to aid in interpretation of groundwater chemistry.

5.3.5 Groundwater Chemistry

This section discusses the constituents required by WAC 173-304; chlorinated hydrocarbons, which are site-specific constituents; and tritium, which is monitored to provide information on groundwater flow direction and flow rate. Total organic halogen (TOX), which is a site-specific constituent, is not discussed because of laboratory problems with the data (see Appendix A).

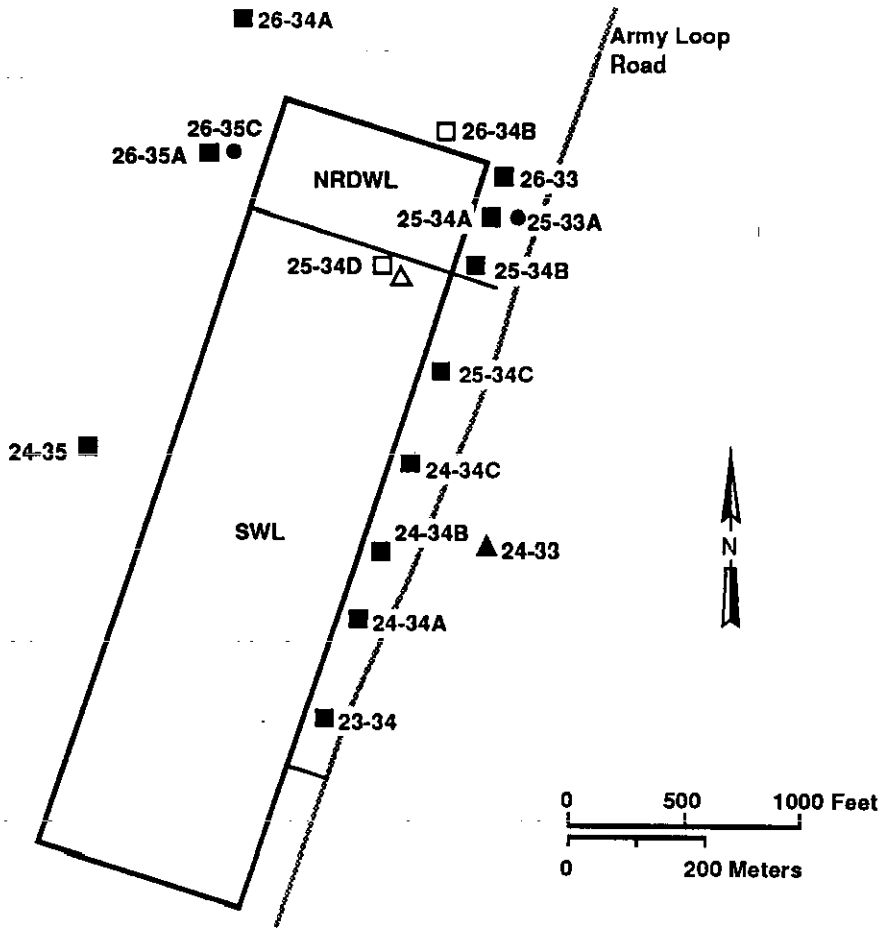
In the following discussion it should be noted that, starting with the July 1993 sampling, the analytical laboratory is reporting concentrations between the method detection limit (MDL) and the contractually required quantitation limit (CRQL). Previously all values below the CRQL were reported as nondetects.

5.3.5.1 Constituents of Concern. Available analytical results for groundwater sampling events from October 1992 through September 1993 are presented in Appendix 5.3A. A summary of results for all required monitoring parameters is provided in Table 5.3-3. Results for chlorinated hydrocarbons are presented in Table 5.3-4. This section discusses the concentration ranges of constituents. Interpretations are provided in Section 5.3.5.2.

5.3.5.1.1 Temperature. Average values for replicate temperature determinations measured during sampling, range from 17.4 to 19.8 °C (63 to 68 °F). There is a tendency for the higher temperatures to occur at the north end of the site, near the axis of the tritium and nitrate plumes.

[1]HydroStar is a registered trademark of Instruments Northwest, Inc.

Figure 5.3-1. Map of the Solid Waste Landfill Showing the Locations of Groundwater Monitoring Wells.



△ Proposed '94 Deep Well
■ Well completed at the top of the unconfined aquifer
● Well completed in the upper Ringold Formation
▲ Well not constructed to RCRA specifications
□ New RCRA wells completed in 1992.

NRDWL Nonradioactive Dangerous Waste Landfill
SWL Solid Waste Landfill

All wells prefixed by 699-

H9012007.95

Table 5.3-1. Monitoring Wells Used for the Solid Waste Landfill.

Well	Aquifer	Sampling frequency	Water levels	Well standard	Other networks
699-23-34[87]	Top of unconfined	Q	M	RCRA	--
699-24-33[48]	Top of unconfined	Q[s]	M	PRE	PNL
699-24-35[87]	Top of unconfined	Q	M	RCRA	--
699-24-34A[87]	Top of unconfined	Q	M	RCRA	--
699-24-34B[87]	Top of unconfined	Q	M	RCRA	--
699-24-34C[87]	Top of unconfined	Q	M	RCRA	--
699-25-34C[87]	Top of unconfined	Q	M	RCRA	--
699-26-35A[86]	Top of unconfined	Q	M	RCRA	NRDWL

Notes: Shading denotes upgradient wells. Superscript following well number denotes the year of installation.
M = frequency on a monthly basis.
NRDWL = Nonradioactive Dangerous Waste Landfill.
PNL = well is sampled by Pacific Northwest Laboratory site-wide monitoring program.
PRE = well was constructed before RCRA-specified standards.
Q = frequency on a quarterly basis.
RCRA = well is constructed to RCRA-specified standards.
[s] = well is sampled for supporting data.

Table 5.3-2. Constituents Analyzed at the Solid Waste Landfill.

Parameters and constituents required by WAC 173-304-490		
Ammonia as nitrogen	Dissolved zinc	Temperature
Chemical oxygen demand	Nitrate	Total coliform
Chloride	Nitrite	Total organic carbon
Conductivity	pH	
Dissolved iron	Sulfate	
Site-specific constituents		
1,1,1-Trichloroethane	Total organic halogen	Trichloroethylene
Others		
Tritium		

Table 5.3-3. 1992 and 1993 Sampling Results for the Solid Waste Landfill. (sheet 1 of 2)

Constituent	TI[a]	Date	23-34A	24-34A	24-34B	24-34C	24-35	25-34C	26-35A
Temperature (°C)	21.0	Dec/92	17.8	17.8	17.6	18.4	17.4	19.4	19.8
		Mar/93	18.4	18.5	18.8	18.2	18.0	18.8	19.6
		July/93	18.5	18.8	18.7	19.1	18.2	19.7	19.4
		Sept/93	19.2	17.9	18.5	18.1	18.1	19.8	19.1
Specific conductance (µmho/cm)	550	Dec/92	616[E]	647[E]	655[E]	751[E]	521	515	422
		Mar/93	608[E]	530[E]	574[E]	670[E]	509	508	411
		July/93	651[E]	598[E]	674[E]	768[E]	569[E]	525	428
		Sept/93	641[E]	596[E]	608[E]	699[E]	491	544	430
Field pH	[6.2, 8.46]	Dec/92	6.9	6.9	7.1	7.0	7.2	7.3	7.6
		Mar/93	6.6	6.7	6.8	6.8	7.0	7.3	7.5
		July/93	6.7	6.7	6.8	7.1	7.4	7.1	7.5
		Sept/93	6.6	6.9	7.0	7.2	7.3	7.3	7.7
Total organic carbon (ppb)	800	Dec/92	<1,000	<1,000	<1,000	<1,000	<1,000	<1,000	<1,000
		Mar/93	<1,000	<1,000	<1,000	<1,000	<1,000	<1,000	<1,000
		July/93	275	<200	300	325	325	<200	<200
		Sept/93	<200	<200	300	325	300	275	525
Chloride (ppb)	9,045	Dec/92	7,100	7,300	7,500	7,800	6,900	7,100	6,800
		Mar/93	7,000	7,200	7,400	7,400	6,600	7,100	6,700
		July/93	7,000	7,200	7,200	7,600	6,600	7,300	6,900
		Sept/93	NA	NA	7,000	7,400	6,400	6,800	6,700
Nitrate (ppb)	33,800	Dec/92	14,000	16,000	21,000	29,000	13,000	31,000	30,000
		Mar/93	13,000	15,000	20,000	28,000	13,500	30,000	29,000
		July/93	13,000	16,000	17,000	27,000	13,000	29,000	28,000
		Sept/93	NA	NA	17,000[M]	25,000[M]	12,000[M]	26,000[M]	26,000[M]
Nitrite (ppb)	109	Dec/92	<200	<200	<200	<200	<200	<200	<200
		Mar/93	<200	<200	<200	<200	<200	<200	<200
		July/93	<200	<200	<38.3	<38.3	<38.3	<200	<200
		Sept/93	NA	NA	<38.3	<38.3	<38.3	<38.3	<38.3
Ammonium (ppb)	100	Dec/92	<100	<100	<100	<100	<100	<100	100
		Mar/93	<100	<100	<100	<100	<100	<100	<100
		July/93	40	50	<38.5	<38.3	40	<38.5	50
		Sept/93	60	60	70	70	90	40	70
Sulfate (ppb)	51,500	Dec/921	48,000	48,000	47,000	44,000	48,000	45,000	41,000
		Mar/93	46,000	45,000	45,000	43,000	47,000	45,000	40,000
		July/93	48,000	49,000	41,000	43,000	46,000	48,000	40,000
		Sept/93	NA	NA	46,000[M]	43,000[M]	45,000[M]	39,000[M]	39,000[M]
Iron, filtered (ppb)	78	Dec/92	<20	70	40	60	40	<20	<20
		Mar/93	110[E]	36	35	50	20	<20	20
		July/93	53	68	50	44	42	40	<10.3
		Sept/93	110[E]	70	35	67	31	61	<10.3
Zinc, filtered (ppb)	34	Dec/92	<10	<10	<10	20	<10	<10	<10
		Mar/93	<10	<10	<10	<10	<10	<10	<10
		July/93	<3.44	<3.34	<3.44	15	8.0	<3.44	<3.44
		Sept/93	<3.44	<3.44	3.70	18	<3.44	5.0	8.7

Table 5.3-3. 1992 and 1993 Sampling Results for the Solid Waste Landfill. (sheet 2 of 2)

Constituent	TI[a]	Date	23-34	24-34A	24-34B	24-34C	24-35	25-34C	26-35A
Manganese, filtered (ppb)	11	Dec/92 Mar/93 July/93 Sept/93	<10 <10 <1.35 <1.35	<10 <10 <11.35 <1.35	<10 <10 1.80 1.90	<10 <10 1.80 3.50	<10 <10 <1.35 1.40	<10 <10 <1.35 2.30	<10 <10 <1.35 <1.35
Chemical oxygen demand (ppb)	3	Dec/92 Mar/93 July/93 Sept/93	<3 <3 NA <3	<3 <3 NA <3	<3 <3 NA <3	<3 <3 NA <3	<3 <3 NA <3	<3 <3 NA <3	<3 <3 NA <3
Coliform bacteria (mpn)	16	Dec/92 Mar/93 July/93 Sept/93	<1 <1 <1 <1	<1 <1 <1 <1	<1 <1 <1 <1	<1 <1 <1 <1	<1 <1 <1 <1	<1 <1 <1 <1	<1 <1 <1 <1

[a]Numbers are obtained from Table 5.3-6 (Background threshold value column).

[E]Exceeding background threshold values.

[N]Laboratory nonconformance report was issued. These replicate averages were excluded from statistical evaluation.

< = data values are less than the contractually required quantitation limit (CRQL). The number given is the respective CRQL.

NA = not available.

TI = tolerance interval (see Section 5.3.5.3).

Table 5.3-4. Ranges of Concentrations (ppb) of Chlorinated Hydrocarbons in Groundwater at the Solid Waste Landfill from October 1992 to July 1993.

	23-34A*	24-34A	24-34B	24-34C	25-34C	24-35	26-35A
1,1,1-Trichloroethane	23-27	16-18	9.4-11	8.0-11	3.4-4.1	2.9-4.2	1.2-1.4
Trichloroethene	3.0-3.4	2.3-2.6	1.6-2.0	1.2-2.0	.75-1.2	<1.0-0.23	<1.0-0.19
Tetrachloroethene	2.7 -5.9	3.4-5.6	3.2-5.5	3.6-5.3	1.0-1.4	0.77-1.2	<0.5-0.33
1,1-Dichloroethane	3.2 -3.7	2.1-2.6	1.6-2.0	1.6-2.3	<1.0-0.35	<1.0-0.34	<0.34-<1.0
Chloroform	<0.5-0.25	<0.5-0.14	<0.5-0.1	<0.5-0.07	<0.5-0.1	<0.5-0.04	<0.5-0.05
Carbon tetrachloride	<1.0-<0.12	<1.0-<0.12	<1.0-<0.12	<0.1-<0.12	<1.0-0.54	<1.0-<0.12	<1.0-0.27
1,1,2-Trichloroethane	<0.5-<0.04	<0.5-<0.04	<0.5-<0.04	<0.5-<0.04	<0.5-<0.04	<0.5-<0.04	<0.5-<0.04
1,2-Dichloroethane	<0.5-<0.14	<0.5-0.63	<0.5-<0.14	<0.5-<0.14	<0.5-<0.14	<0.5-<0.14	<0.5-<0.14
Cis-1,2-Dichloroethene	<1.0-<0.13	<1.0-0.17	<1.0-<0.13	<1.0-<0.13	<1.0-<0.13	<1.0-<0.13	<1.0-<0.13
Trans-Dichloroethene	<1.0-<0.15	<1.0-<0.15	<1.0-<0.15	<1.0-<0.15	<1.0-<0.15	<1.0-<0.15	<1.0-<0.15

*All well numbers prefixed by 699-.

5.3.5.1.2 Conductivity. Average values for replicate conductivity measurements carried out during sampling range from 411 to 751 μmho/cm. One replicate average, for monitoring well 699-24-34C collected in December 1992, exceeds the Ecology Secondary Standard for Public Water Supplies (WAC 248-54) of 700 μmho/cm. The background threshold value of 550 μmho/cm was exceeded for all samples from downgradient wells 699-23-34, 699-24-34A, 699-24-34B, and 699-24-34C.

5.3.5.1.3 pH. Average values for replicate pH measurements made at the time of sampling range from 6.7 to 7.7. None of the pH measurements exceed the background threshold range of 6.2 to 8.46. As in the past, the lower values tend to occur in the southernmost downgradient monitoring wells.

5.3.5.1.4 Chloride. Chloride concentrations in the groundwater monitoring wells range from 6,400 to 7,800 ppb during the reporting period. None of the chloride concentrations exceed the background threshold concentration of 9,045 ppb.

5.3.5.1.5 Nitrate. Nitrate concentrations in the groundwater monitoring wells at the SWL have ranged from 13,000 to 31,000 ppb during the reporting period. None of the reported nitrate concentrations exceed the background threshold concentration of 33,800 ppb or the Ecology groundwater protection standard (WAC 173-200) of 45,000 ppb. The distribution of nitrate is very similar to that of tritium (see below) and is believed to have a similar source, which is waste disposal in the 200 Areas. A peak of nitrate concentrations apparently has passed beneath the site and nitrate concentrations are currently declining.

5.3.5.1.6 Nitrite. All nitrite analytical results are reported as below the CRQL of 200 ppb or the MDL of 38.3 ppb for the reporting period.

5.3.5.1.7 Ammonium. All ammonium ion analytical results are at or are below 100 ppb for the reporting period. Most results were reported as less than either the CRQL of 100 ppb or the MDL of 38.3 ppb. However, several values were reported between the CRQL and MDL. Of these reported values the highest (100 and 90 ppb) were reported for upgradient wells 699-24-35 and 699-26-35A, respectively.

5.3.5.1.8 Sulfate. Reported sulfate concentrations ranged from 39,000 to 49,000 ppb during the reporting period. None of the reported sulfate concentrations exceeded the background threshold concentration of 51,000 ppb.

5.3.5.1.9 Dissolved Iron. Reported values for filtered iron show a high degree of variability, ranging from <10.3 to 110 ppb during the reporting period. Reported filtered iron concentrations exceeded the background threshold value of 78 ppb in well 699-23-34 during the reporting period.

5.3.5.1.10 Dissolved Manganese. Most filtered manganese results are reported as either below the CRQL of 10 ppb or below the MDL of 1.35 ppb for the reporting period. A few values above the MDL were reported, the highest being a concentration of 3.5 ppb in well 699-24-34C.

5.3.5.1.11 Dissolved Zinc. Reported values for filtered zinc ranged from <3.44 to 20 ppb for the reporting period. The highest reported filtered zinc concentration occurred in monitoring well 699-24-34C where three values fell in the 15- to 20-ppb range during the reporting period.

5.3.5.1.12 Chemical Oxygen Demand. Reported values for chemical oxygen demand (COD) are all below the CRQL and background threshold concentration of 3 ppm for the reporting period.

5.3.5.1.13 Total Organic Carbon. Total organic carbon (TOC) concentrations reported for December 1992 and March 1993 are below the CRQL of 1,000 ppb. TOC concentrations reported for July and September 1993 ranged from below the MDL of 200 to 525 ppb. The value of 525 ppb is for upgradient well 699-26-35A and was reported with a laboratory flag, indicating blank contamination.

5.3.5.1.14 Total Coliform. All reported values for total coliform for this reporting period are below the CRQL of 1 colony/100 mL.

5.3.5.1.15 Total Organic Halogen. TOX values for the reporting period are considered suspect because of the results of a laboratory audit (see Appendix A) and will not be considered further in this report.

5.3.5.1.16 Chlorinated Hydrocarbons. A number of chlorinated hydrocarbons have been detected at the SWL in low concentrations. These include 1,1,1-trichloroethane (111-TCA), trichloroethene (TCE), tetrachloroethene (PCE), 1,1-dichloroethane (11-DCA), and chloroform. Several of these constituents occur in low concentrations in the upgradient wells; however, the highest concentrations consistently occur in the southernmost downgradient well (699-23-34).

Analysis of one sample, taken from well 699-24-34C in December 1991, indicated the presence of carbon tetrachloride (4.0 ppb), 1,1,2-trichloroethane (0.5 ppb), 1,2-dichloroethane (0.5 ppb), cis-1,2-dichloroethene (1.3 ppb), and trans-dichloroethene (1.7 ppb). These compounds have not been found in previous or subsequent analyses and it is uncertain whether they are representative of groundwater composition or analytical variation.

The range of reported concentrations in downgradient wells at the SWL has not changed significantly since the first detection of chlorinated hydrocarbon at the site. The range of reported concentrations of chlorinated hydrocarbons at the SWL during this reporting period are given in Table 5.3-4. Reported concentrations for groundwater samples exceed Ecology groundwater protection standards (WAC 173-200) for TCE (3 ppb), PCE (0.8 ppb), and 11-DCA (1 ppb).

5.3.5.1.17 Tritium. Tritium was added to the SWL constituent list in 1989 as an aid in determining groundwater flow directions and flow rates at the SWL. Tritium concentrations in groundwater monitoring wells at the SWL have ranged from 19,300 to 265,000 pCi/L during the reporting period and are currently decreasing. The tritium concentrations in all SWL monitoring wells

have been above the Washington State and U.S. Environmental Protection Agency primary drinking water standard (40 *Code of Federal Regulations* [CFR] 141) of 20,000 pCi/L during the current reporting period. Tritium concentrations dropped below 20,000 pCi/L in upgradient well 699-24-35 and downgradient well 699-23-34A in September 1993.

5.3.5.2 Interpretation of Groundwater Chemistry. Downgradient wells at the SWL have higher specific conductance, alkalinity, total carbon, and cation concentrations than upgradient wells. As indicated in DOE-RL (1991a, 1991b, 1992, and 1993a), it is believed that this is a result of high vadose concentrations of CO_2 beneath the SWL. High vadose zone concentrations of CO_2 are indicated by the vadose zone gas surveys of Evans et al. (1989) and Jacques and Kerkow (1993). Solution of CO_2 in groundwater produces carbonic acid (H_2CO_3). Carbonic acid lowers groundwater pH, making it more reactive with aquifer materials. Reaction with aquifer materials, principally hydrolysis of silicates, results in the dissolution of cations with a resultant increase in groundwater pH. The aquifer materials in effect act as a pH buffer. The dissolution of CO_2 is indicated by concentrations of inorganic carbon (total carbon minus TOC) which are 30 to 40% higher in downgradient wells than in upgradient wells. At the ambient groundwater pH almost all of this inorganic carbon will exist in the form of the bicarbonate ion (HCO_3^-).

A number of chlorinated hydrocarbons have been detected in groundwater at the SWL, the most important being 111-TCA, PCE, TCE, and 11-DCA (see Table 5.3-4). 111-TCE occurs at the highest concentrations (Figure 5.3-2); however, it is far below the groundwater protection standard (GPS) of WAC 173-200 (200 ppb). PCE occurs in the 1- to 6-ppb range (Figure 5.3-3), above the GPS of 0.8 ppb in all downgradient wells and in one measurement for upgradient well 699-24-35. TCE occurs in the 1- to 4-ppb range (Figure 5.3-4) and is above the GPS (3 ppb) for well 699-23-34A at the southern end of the downgradient network. 11-DCA occurs in the 1- to 4-ppb range (Figure 5.3-5) and is above the GPS (1 ppb) in the four southernmost downgradient wells.

The southernmost monitoring wells at the landfill have had the highest concentrations of chlorinated hydrocarbons since the initiation of sampling in 1988. The concentrations generally increase from north to south along the line of downgradient wells, indicating that the highest concentrations occur somewhere south of a line connecting upgradient well 699-24-35 and downgradient well 699-23-34A. How far south of this line the peak concentrations occur and how high these concentrations may be is unknown.

The most likely cause of the widespread contamination with chlorinated hydrocarbons at the SWL, including upgradient wells and the adjacent NRDWL, is the dissolution of vadose zone vapors into groundwater. However, the source of the vadose zone vapors is somewhat uncertain. The source could be chlorinated hydrocarbons trapped within the vadose zone or dense nonaqueous phase liquids within the aquifer. The apparent location of the highest concentrations near the south end of the landfill may indicate that the source is migrating southward (downdip) either within the vadose zone or the aquifer. The source of the chlorinated hydrocarbons beneath the SWL is highly uncertain.

Figure 5.3-2. Plot of 1,1,1-Trichloroethane Concentrations (ppb) in Downgradient Wells at the SWL and NRDWL from April 1990 to July 1993.

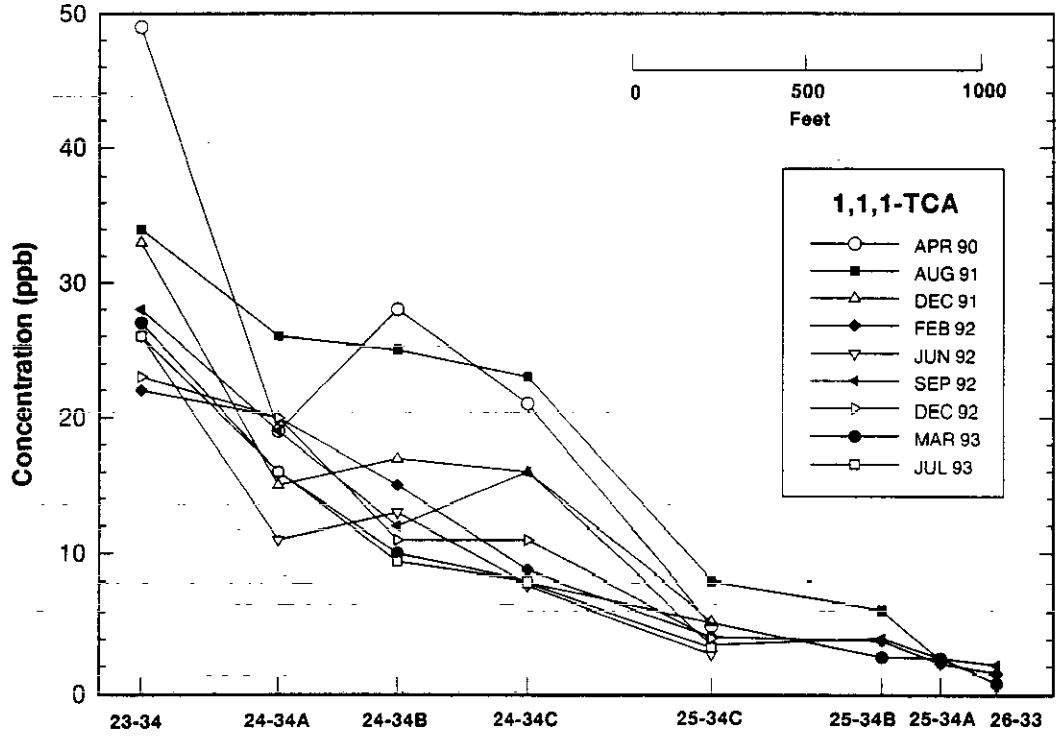


Figure 5.3-3. Plot of Tetrachloroethene (PCE) Concentrations (ppb) in Downgradient Wells at the SWL and NRDWL from April 1990 to July 1993. (GPS indicates the Groundwater Protection Standard of WAC 173-200.)

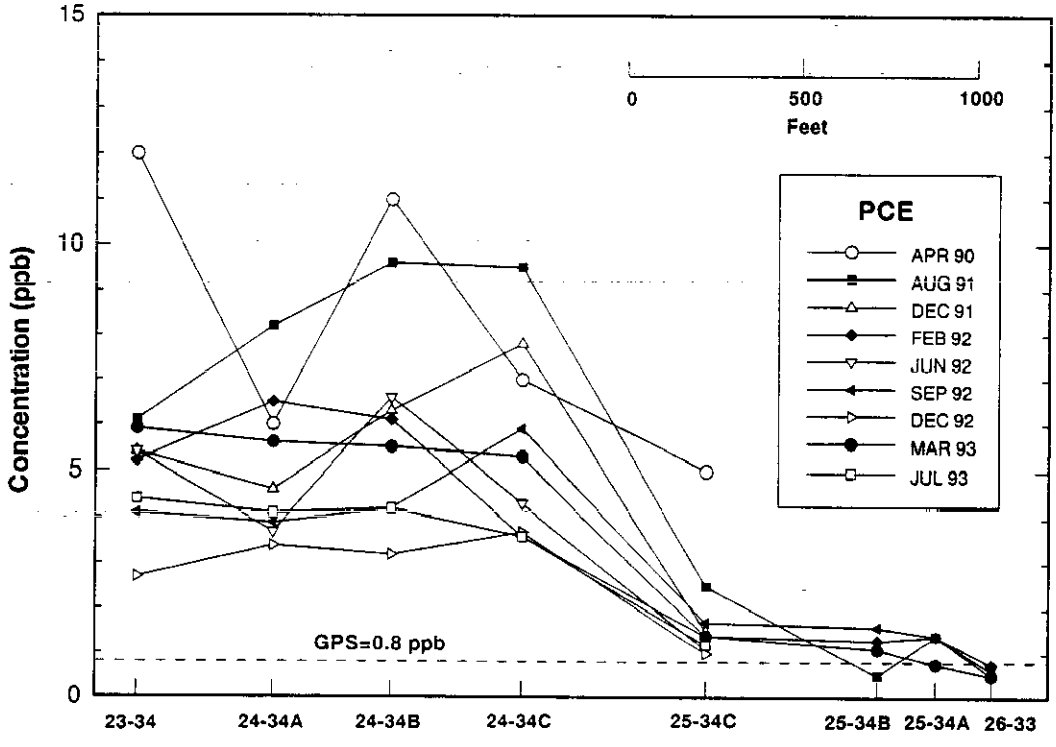


Figure 5.3-4. Plot of Trichloroethene (TCE) Concentrations (ppb) in Downgradient Wells at the SWL and NRDWL from April 1990 to July 1993. (GPS indicates the Groundwater Protection Standard of WAC 173-200.)

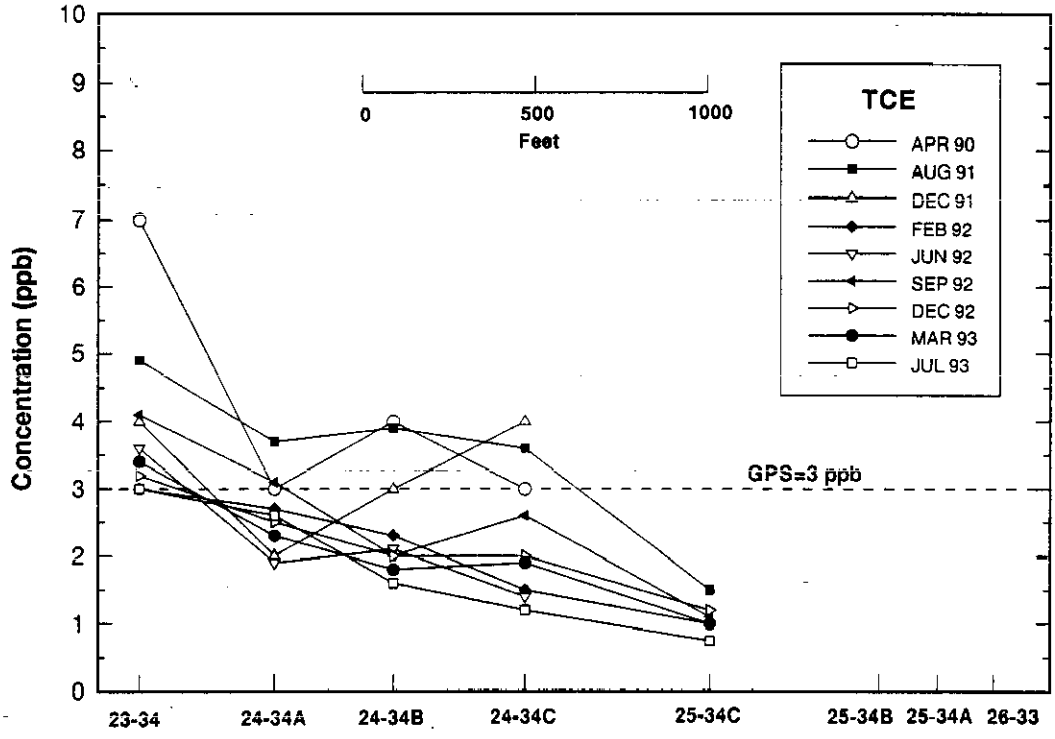
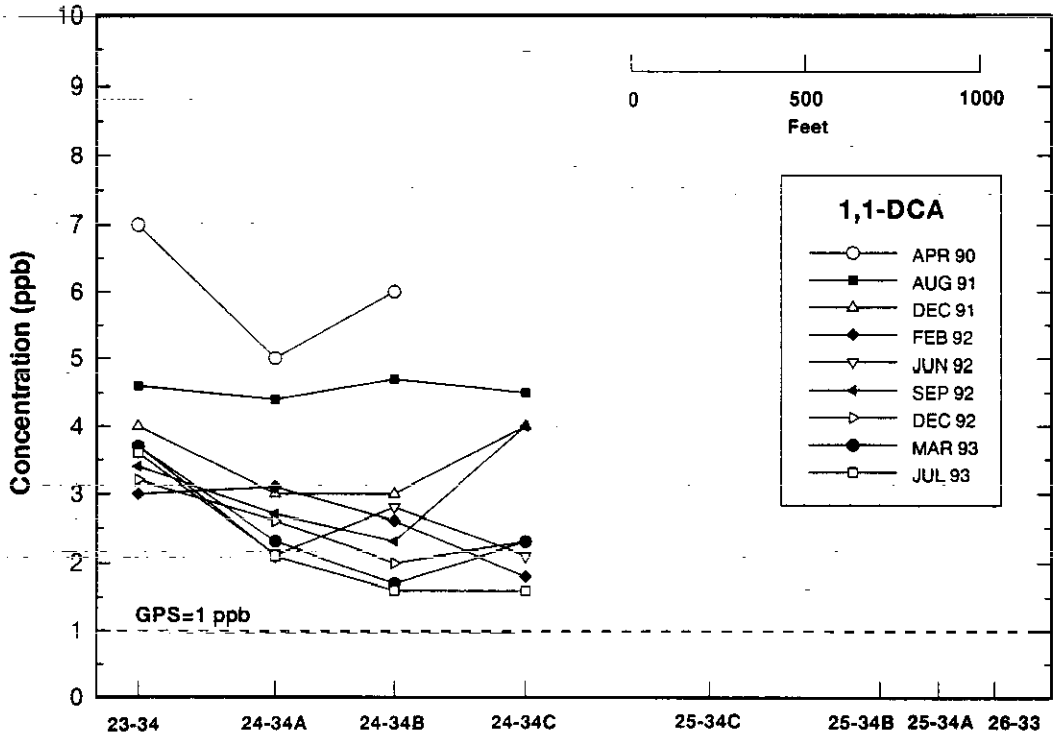


Figure 5.3-5. Plot of 1,1-Dichloroethane (11-DCA) Concentrations (ppb) in Downgradient Wells at the SWL and NRDWL from April 1990 to July 1993. (GPS indicates the Groundwater Protection Standard of WAC 173-200.)



The major concentration axes of the 200 East Area nitrate and tritium plumes pass directly beneath the SWL as indicated in Section 5.1. Tritium and nitrate concentrations in well 699-24-33, located approximately 150 m (500 ft) east (downgradient) of the SWL, are decreasing (Figure 5.3-6), indicating that a maximum in the plumes has passed beneath the SWL. This decrease in tritium concentrations is confirmed by reported concentrations in SWL monitoring wells. However, it also appears that the concentration axis of the tritium plume is shifting northward as it decreases (Figure 5.3-7), possibly as a result of decreasing effluent input to B Pond. Nitrate concentrations beneath the SWL exhibit a pattern similar to that of tritium and are currently decreasing.

5.3.5.3 Statistical Evaluation. Statistical evaluation of data for this year at the SWL consisted of the required comparisons between upgradient and downgradient wells for determining whether a significant change over background has occurred for constituents specified in WAC 173-304-490. WAC 173-304 does not require replicate analyses. Thus, the tolerance interval method, suitable for individual sample comparisons, was chosen because of the lack of replicated analyses for most of the constituents of concern. Statistical evaluations are described as follow.

Calculation of background summary statistics--Summary statistics were calculated using background samples for the site (see DOE-RL 1993a, Appendix D, Table D10.1). The results are presented in Table 5.3-5. Some of the background data are below the contractual detection limits required of the U.S. Testing Company or below the CRQL. In cases where measured values are available (e.g., most of the TOC values), these values were used in calculating the summary statistics. In cases where the proportion of nondetects is between 15 and 50%, less-than values were replaced by half of their contractual detection limits and/or CRQL, and the usual calculations were performed (e.g., filtered iron). In cases where the proportion of nondetects is greater than 50%, summary statistics are not calculated (e.g., nitrite, ammonium, filtered zinc, filtered manganese, coliform, and COD).

Testing the assumption of normality of data--The tolerance interval defines a concentration range (from background well data) that contains at least a specified proportion (coverage) of the population with a specified probability (confidence level). There are two types of tolerance intervals: parametric and nonparametric. Parametric tolerance interval techniques are sensitive to the assumption that the data are drawn from a normal population. The statistical tests used for evaluating whether or not the data follow a specified distribution are called goodness-of-fit tests. The Lilliefors test is used to evaluate the fit of a hypothesized normal or lognormal distribution. Test procedures are described by Conover (1980). STATGRAPHICS[1] (Version 4.2) was used to calculate the Lilliefors test statistics. If the data are not normal, the Lilliefors test was applied to the logarithm (natural logarithm) of the data to see if the transformed data are approximately normal. This is equivalent to testing the hypothesis that

[1]STATGRAPHICS is a trademark of Statistical Graphics Corporation.

Figure 5.3-6. Time Series Plot of Tritium (pCi/L) and Nitrate (ppb) Concentrations in Downgradient Well 699-24-33.

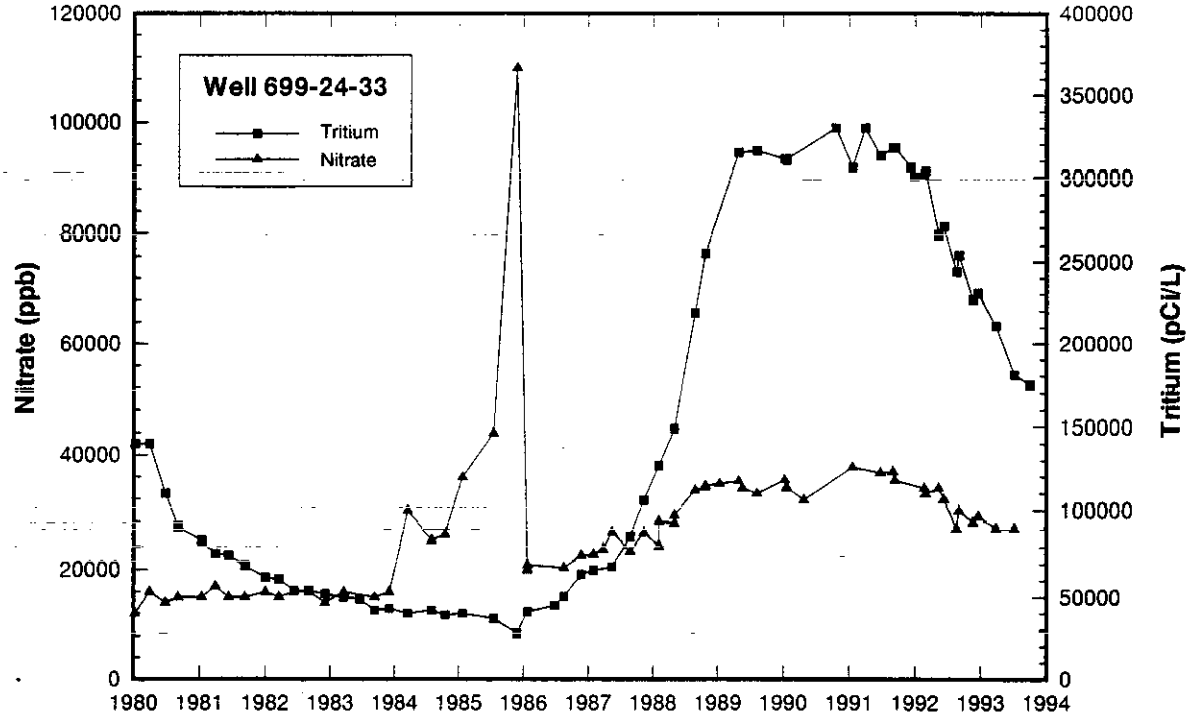


Figure 5.3-7. Plot of Tritium Concentrations (pCi/L) in Downgradient Monitoring Wells for the SWL and NRDWL. (All Well Numbers Along Horizontal Axis are Prefixed by 699-).

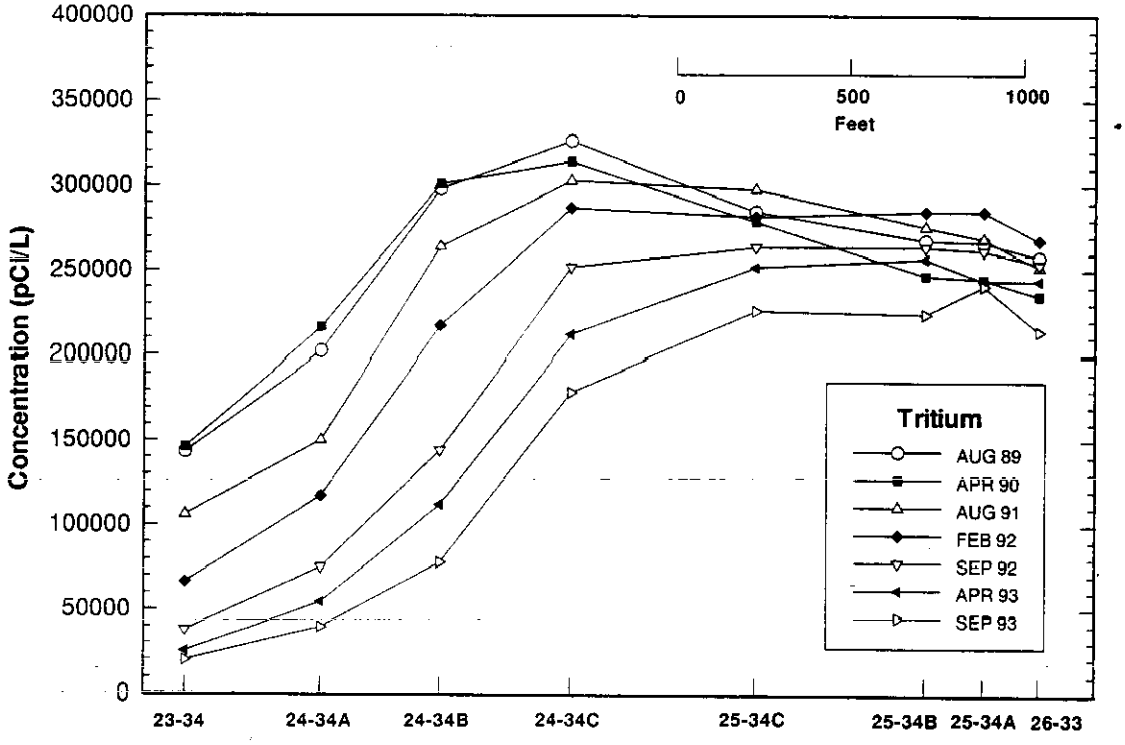


Table 5.3-5. Summary Statistics for the Background Monitoring Constituent Parameter Data for the Solid Waste Landfill.

Constituent	n	GT	LT	Mean	Median	Std. Dev.	CV (%)	Min.	Max.
Temperature[a]	22	22	0	18.7	18.8	1.00	5.4	16	20.4
Specific[a] conductance	38	38	0	385.3	397	68.9	17.9	206	550
Field pH Field pH[b]	38 36	38 36	0 0	7.23 7.33	7.29 7.31	0.62 0.46	8.5 6.3	5.4 6.08	8.45 8.45
TOC[c,d]	38	0	38	421.6	468	142.9	33.9	32	750
Chloride	36	36	0	7,341	7,280	798.4	10.9	6,000	8,660
Nitrate	36	36	0	25,929	27,725	5,139.2	19.8	16,000	33,800
Nitrite	24	0	24	BDL	BDL	NC	NC	BDL	BDL
Ammonium	24	4	20	BDL	BDL	NC	NC	BDL	100
Sulfate	36	36	0	44,169	46,000	4,695.0	10.6	34,000	51,500
Iron[a], filtered	29	16	13	33.3	28	19.3	58.0	BDL	78
Zinc, filtered	29	14	15	BDL	BDL	NC	NC	BDL	34
Manganese, filtered	29	1	28	BDL	BDL	NC	NC	BDL	11
Coliform[a] bacteria	29	2	27	BDL	BDL	NC	NC	BDL	16
Chemical oxygen demand	8	0	8	BDL	BDL	NC	NC	BDL	BDL

[a]Measuring unit for temperature is °C; conductivity is μmho/cm; coliform bacteria is colonies/100 mL; all chemical components are in ppb.
[b]Inconsistent pH values of 5.4 and 5.5 were excluded.
[c]Indicates that statistics were calculated from values reported below contractually required detection limit (CRDL) (see Appendix B, Table B10.1 and its footnotes).
[d]Less than detection values were replaced by one-half of the CRDL in the calculation of summary statistics.
BDL = below CRDL.
CV = coefficient of variation.
GT = number of samples that are greater than the CRQL.
LT = number of samples that are less than the CRQL.
n = total number of samples.
NC = not calculated because of insufficient measured values.

the concentration measurements follow a lognormal distribution. If the proportion of nondetects is more than 15%, a goodness-of-fit test is not performed and a nonparametric tolerance interval will be calculated to the extent possible.

Results of the Lilliefors test are presented in Table 5.3-6. Temperature, field pH, and chloride concentration measurements from background wells are approximately normally distributed. Specific conductance, TOC, nitrate, and sulfate concentrations are neither normal nor lognormal.

Establishing background levels--Tolerance intervals are constructed from the data on background wells. Both the upper and lower bounds of the interval (two-sided) were calculated for field pH. For other constituents of concern only the upper bounds of the intervals (one-sided) were calculated.

If a normal (or a lognormal) distribution is a reasonable approximation of the background concentrations, a parametric tolerance interval of the following form is calculated:

$$T.I. = \bar{X}_b \pm KS_b \text{ (two-sided) or } T.I = \bar{X}_b + KS_b \text{ (one-sided)} \quad (1)$$

where:

$\bar{X}_b$ = Background mean

K = A normal tolerance factor, which depends on the number of background samples (n), coverage (P%), and confidence level (Y). A coverage of 95% and confidence level of 95% are recommended (EPA 1989). With n = 16, P = 95%, and Y = 95%, K is 2.523 (K is 2.566, if n = 15) for a one-sided normal tolerance interval (Natrella 1966)

S_b = Background standard deviation.

If background concentrations do not follow a normal or a lognormal distribution, a nonparametric tolerance interval can be constructed (Conover 1980). A two-sided nonparametric tolerance interval is just the range of the observed data. An upper one-sided nonparametric tolerance limit is the largest observation. The number of background samples determines the coverage (P%) and the probability level (Y) associated with that proportion. For a one-sided 95% (P = 95%) nonparametric tolerance interval with 95% (Y = 95%) probability, the number of background samples required is 59 (Conover 1980). With only 15 background samples (nitrate, filtered iron, and filtered zinc), the coverage is 85% and the confidence level is 90%. That is, the upper one-sided tolerance limit defined by the largest background concentration contains at least 85% of the background population with 90% probability. More background samples are needed if a larger coverage and/or a larger probability level are desired.

Table 5.3-6. Results of Lilliefors Test for Normality and Background Threshold Values for the Solid Waste Landfill.

Constituent (unit)	Test statistic (raw data)	Test statistic (log value)	Upper tolerance limit	Background threshold value[a]
Temperature (°C)	0.115 n.s.	NA	21.0[b]	21.0
Specific conductance (μmho/cm)	0.162 s.	0.207 s.	550[c]	550
Field pH Field pH[a]	0.140 n.s. 0.089 n.s.	NA NA	[5.7, 8.75][b] [6.2,8.46][b]	[6.2, 8.46]
Total organic carbon (ppb)	0.191 s.	0.181 s.	750[c] 800[d]	800
Chloride (ppb)	0.104 n.s.	NA	9,045[b]	9,045
Nitrate (ppb)	0.168 s.	0.195 s.	33,800[c]	33,800
Nitrite (ppb)	NC	NC	109[d]	109
Ammonium (ppb)	NC	NC	100[c] 54[d]	100
Sulfate (ppb)	0.179 s.	0.190 s.	51,500[c]	51,500
Iron, filtered (ppb)	NC	NC	78[c] 54.0[d]	78
Zinc, filtered (ppb)	NC	NC	34[c] 21.2[d]	34
Manganese, filtered (ppb)	NC	NC	11[c] 6.2[d]	11
Coliform (mpn)	NC	NC	16[c] 1[e]	16
Chemical oxygen demand	NC	NC	3[e]	3

[a]Background threshold value for each constituent is the larger of the upper tolerance limit or the applicable limit of quantitation (LOQ).
[b]Based on normal distribution.
[c]Maximum value reported; for pH range reported.
[d]Based on LOQ (see Appendix A).
[e]Based on contractually required detection limit (see Table 5.3-5 and its footnotes).
NA = not applicable.
NC = not calculated because of insufficient measured values.
n.s. = not significant at 0.05 level of significance.
s. = significant at 0.05 level of significance.

In cases where all of the background values are below the contractually established detection limits or where the proportion of nondetects is more than 15%, a limit of quantitation (LOQ) was also calculated from the U.S. Testing Company laboratory blanks data (see Appendix A). Following the guidance in the *RCRA Ground Water Monitoring Technical Enforcement Guidance Document (TEGD)* (EPA 1986), it was decided that for cases where the calculated upper tolerance limit is below the LOQ, the LOQ will be used as the background threshold value (i.e., comparison value) between background and downgradient wells. This approach makes use of laboratory quality control data to target the limits of quantifiable data and provides a realistic approach for upgradient/downgradient well comparisons when a facility upgradient well yields values that are below the detection limit. In cases where LOQ is not available (e.g., coliform and COD), the CRQLs were used as the background threshold values. Note that a narrower range for pH, after removing inconsistent pH values, is used as the comparison value. The resulting tolerance limits, LOQs, and background threshold values are also presented in Table 5.3-6.

Comparisons with background levels--Once the background threshold values are established, data from compliance-point wells were compared individually with these background concentration levels. If the background levels are exceeded, it is interpreted as providing evidence of statistically significant contamination.

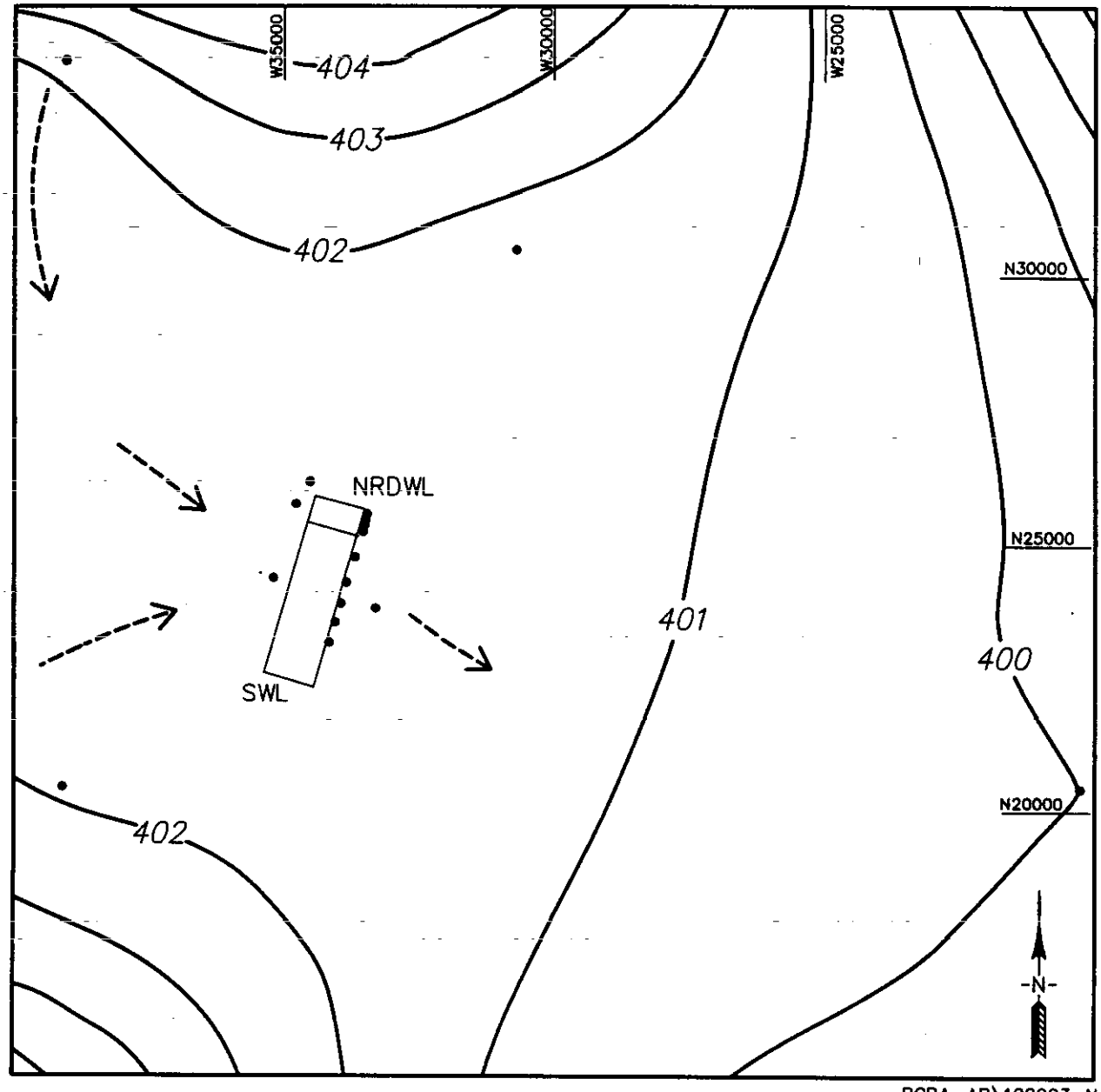
The sampling results from 1993 were compared to the background levels established earlier. The results are presented in Table 5.3-4 and discussed in Section 5.3.5.2. Values for specific conductance exceed the background level in downgradient wells 699-23-34, 699-24-34A, 699-24-34B, and 699-24-34C for all samplings during this reporting period. This pattern of exceedances is similar to those observed in 1990, 1991, and 1992, and is discussed in the 1990 RCRA groundwater monitoring annual report (DOE-RL 1991b). In addition, the background threshold was exceeded for filtered iron in downgradient monitoring well 699-23-34A for the March and September 1993 samplings.

5.3.6 Groundwater Flow

Water table elevations were determined at the time of groundwater sampling; monthly water level measurements were made for all SWL wells during 1992. The discussions of water table elevations, groundwater flow directions, and groundwater flow velocities are based on the monthly measurements. The 1992 water level measurements for the SWL monitoring network are listed in Appendix 5.3B.

5.3.6.1 Groundwater Flow Direction. The SWL lies in a zone of very high transmissivities (Section 5.1) and, as a result, there is a very low hydraulic gradient across the site. A map of the water table in the vicinity of the site, based on June 1993 data, is presented in Figure 5.3-8. This map illustrates the low hydraulic gradients in the vicinity of the SWL. The zone of high transmissivities, which includes the SWL, extends to the northwest beneath the southeast corner of the 200 East Area. Groundwater flows into this zone from the B Pond mound to the north, and from the U Pond mound to the west. The principal effect is apparently the input to B Pond, which has a strong affect on the water table elevation in the vicinity of the SWL.

Figure 5.3-8. Water Table Map (Potentiometric Surface) for the Vicinity of the Solid Waste Landfill Based on June 1993 Water Table Measurements. (Datum is Mean Sea Level).



The water table in the vicinity of the SWL has dropped more than 1.3 m (>4 ft) since December 1988, apparently as a result of decreased water input to B Pond. This decrease in the water table is illustrated in Figure 5.3-9, which are hydrographs showing monthly water level measurements in SWL wells. These hydrographs indicate the low hydraulic gradient across the SWL.

Groundwater flow directions beneath the SWL are indicated by both the water level measurements and by the paths of nitrate and tritium plumes that originate in the 200 East Area and pass beneath the SWL. The nitrate and tritium plumes in 1990 indicated that the principal direction of groundwater flow beneath the SWL was approximately 125° east of north (DOE-RL 1991b), a value confirmed by current groundwater chemistry data. The difference in water table elevation across the site is commonly on the order of 1 cm (0.03 ft), well within the error expected from well surveying and water table elevation measurements. However, flow directions based on water table elevations agree to some extent with the flow direction indicated by the plumes. Previous determinations using water level measurements yield flow directions ranging from 107 $\pm$ 36° east of north to 139 $\pm$ 15° east of north (DOE-RL 1991b, 1992). Flow direction estimates from 1993 water level data, using two sets of wells and weeding out apparent fliers, are 132 $\pm$ 25° east of north (n=8) and 96 $\pm$ 28° east of north (n=10). The flow directions indicated by the contaminant plumes are probably the more accurate and the true groundwater flow direction is approximately 125° east of north.

5.3.6.2 Rate of Flow. The rate of groundwater flow beneath the SWL is highly uncertain. The aquifer beneath the SWL is characterized by high transmissivities and very low gradients. On the basis of site-specific aquifer testing and the observed hydraulic gradients, the expected groundwater velocities should be on the order of 1.2 to 1.8 m/d (4 to 6 ft/d) (Weekes et al. 1987). However, more direct velocity indicators indicate a range of much higher values. Transport velocities in the 200 East Area, indicated by contaminant transport within the Hanford formation, indicate groundwater flow velocities between 3 and 4.3 m/d (10 to 14 ft/d) (Wilber et al. 1983). Tracer tests in the area southeast of the 200 East Area indicated groundwater velocities in excess of 30 m/d (100 ft/d); however, they occurred at higher hydraulic gradients than exist today (Bierschenk 1959). Tracking of the present tritium and nitrate plumes from wells several miles upgradient from well 699-24-33, east of the SWL, indicates contaminant transport rates in excess of 6 m/d (20 ft/d). In addition, the recent decrease in nitrate and tritium concentrations is indistinguishable in quarterly sampling of upgradient and downgradient wells (Figure 5.3-10), indicating that the time required for the contaminants to traverse the site is less than 3 months. This traverse time indicates groundwater transport rates greater than 5.5 m/d (18 ft/d). The actual transport rate is probably near 6 m/d (20 ft/d) and is controlled by zones of very high groundwater velocity within the Hanford formation that are missed or averaged out in normal aquifer testing.

5.3.6.3 Evaluation of Monitoring Well Network. The present groundwater flow direction at the SWL is oblique to the site boundary. As a result the southern portion of the compliance point is not adequately covered by the present monitoring network. Two new downgradient wells are planned for fiscal

Figure 5.3-9. Hydrograph Showing Monthly Water Level Measurements (Feet Above Mean Sea Level) for the Solid Waste Landfill.

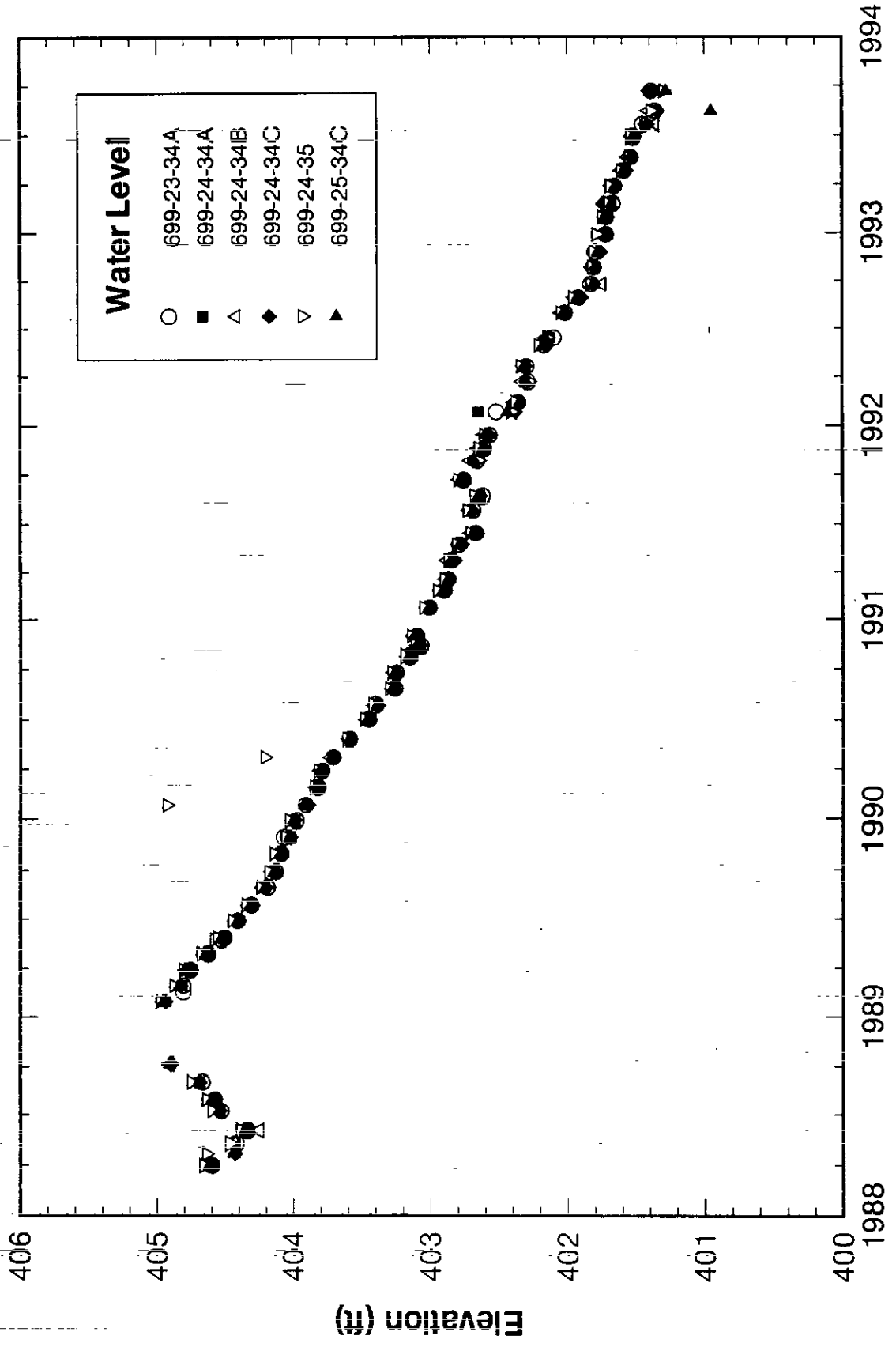
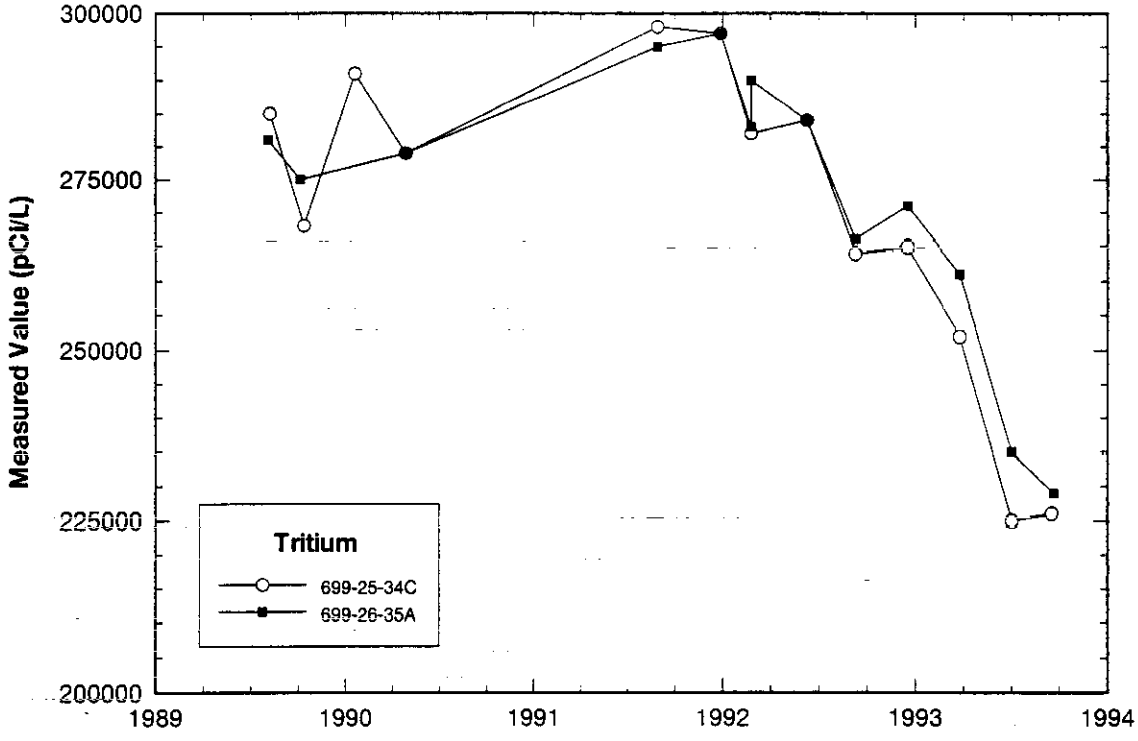
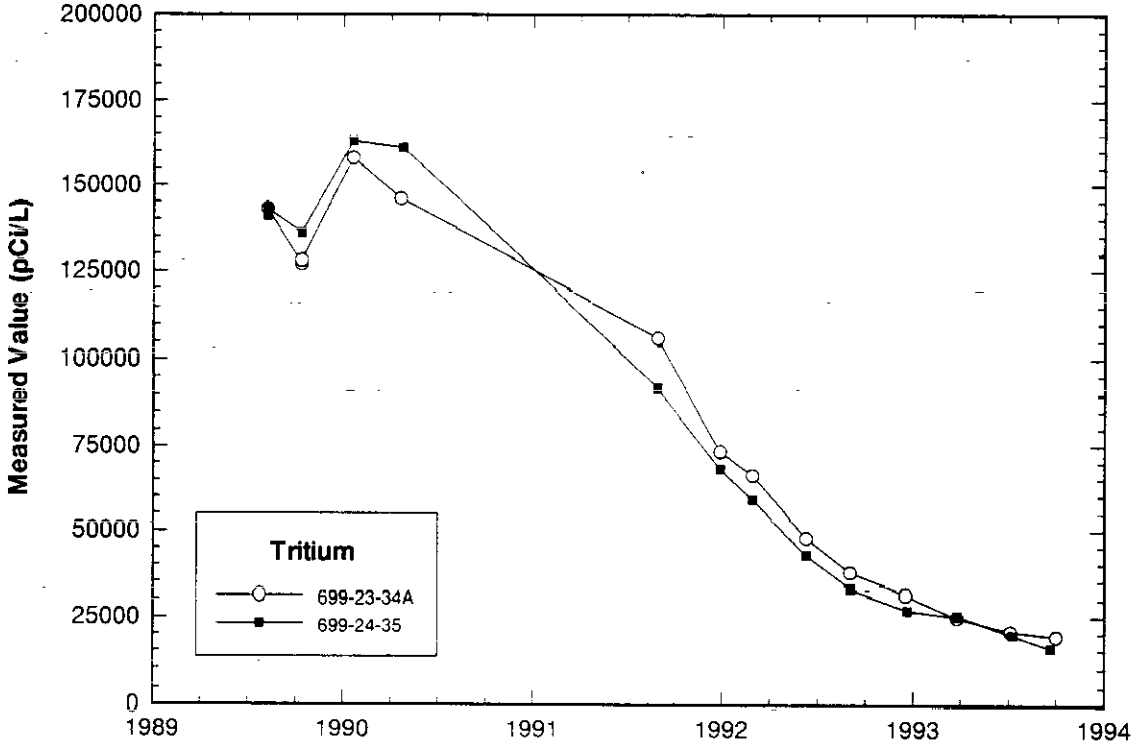


Figure 5.3-10. Time Series Plots of Tritium Concentrations (pCi/L) in Upgradient-Downgradient Well Pairs: (a) Wells 699-26-35A and 699-25-34C; (b) Wells 699-24-35 and 699-23-34A.





year 1993 to complete the compliance-point monitoring network at the SWL. The justification and descriptions of the proposed new wells, which raise the MEMO (Jackson et al. 1991) monitoring efficiency from 68 to 94%, is presented in WHC (1993).

5.3.7 References

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APPENDIX 5.3A

CHEMICAL ANALYTICAL DATA

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APPENDIX 5.3A

CHEMICAL ANALYTICAL DATA

5.3A.1 DATA TABLES

Four different formats are used to display water level measurements and groundwater sample analytical results. This section describes the meaning of each table column heading, defines the abbreviations used, explains the data qualifiers and flags, and lists analysis method codes and relevant regulatory standards.

A new hazardous chemical laboratory contract became effective for samples received on or after April 26, 1993. The new contract contains some changes to the contractually required quantitation limits (CRQL) and a change in how results below the CRQL are reported. In the old contract, analytical results below the CRQL were reported with the CRQL value followed by a U qualifier. In the new contract, results below the CRQL but above the method detection limit (MDL) are reported with the measured value followed by an L qualifier. Results below the MDL are reported with the MDL value followed by a U qualifier. This document may contain data processed through both the old and the new contracts and therefore may contain data reported by both methods. The sample collect date is a good indicator of which contract was in place because samples are typically collected no more than 1 day before they are received by the laboratory. Note that all CRQL values shown in the data tables are the new contract values, even if some of the data were processed under the old contract.

5.3A.1.1 Water Level Measurement Report

The Water Level Measurement Report has four columns as follows:

- Well--Well in which measurement was made.
- Date--Date of measurement.
- Depth to water--Depth, in feet, from well casing reference point to top of water in well.
- Water level--Elevation, in feet above mean sea level, of water level computed by subtracting depth to water from casing reference elevation.

Wells are grouped according to the zone that they monitor beginning with the top of the unconfined aquifer and continuing downward to the confined aquifer.

Only measurements made during the reporting quarter are included in the tables. In addition to measurements made during sampling, which are marked with an asterisk (*), measurements are routinely performed at other times to permit collection of data for an entire network within a 1- or 2-day time period.

Data that are judged to be suspect by the project scientist are flagged with '+' in the table. Before data are designated as suspect, checks are conducted to determine if a transcription error occurred between the field sheet and the electronic database.

5.3A.1.2 Constituent List and Summary of Results

The Constituent List and Summary of Results table (Summary table) is the first of three tables that present the results of groundwater sample analyses. The Summary table displays statistics based on the complete data set for the reporting period. The complete data set consists of all analysis results requested by the project that arrived at Westinghouse Hanford Company between the cutoff date for the previous quarterly report and the cutoff date for the current quarterly report, and are associated with samples collected before the end of the current reporting quarter. Therefore, data collected during previous quarters may appear in this document if the laboratory did not report the data until the current reporting period.

The fields in the Summary table are as follows:

- Constituent name--Name of the analyzed constituent being summarized; the Short name is an abbreviation used in the Constituents with at Least One Value Above the CRQL table (Section 5.3A.1.3); the (Method), when present, is a code (Section 5.3A.1.5) used to distinguish between different analytical methods for the same constituent.

- Units--Units in which the CRQL and drinking water standards (DWS) are reported in this table.

- Laboratory CRQL--CRQL imposed on the laboratory. This field is blank for radionuclides where the CRQL is defined as the value of the total error reported by the laboratory for each result.

- Drinking water standard limit/agency--The DWS used for comparison to the reported results; see Section 5.3A.1.5 for Agency definitions and a complete listing of standards used.

- Number of samples--Total is the number of sample results from all wells in the project contained in the complete data set for that constituent; >CRQL is the number of results that exceed the CRQL; >DWS is the number of results that exceed the listed DWS.

Summarized constituents are grouped as Contamination Indicator Parameters (CIP), Drinking Water Parameters, Groundwater Quality Parameters, and Site-Specific and Other Constituents. Within groups, rows are ordered alphabetically by the full constituent name.

Several constituents have CRQLs that exceed the DWS. In such cases, exceedance of the DWS cannot be determined if the constituent is not detected, so an asterisk (*) is placed in the >DWS field.

5.3A.1.3 Constituents with at Least One Value Above the CRQL

The Constituents with at Least One Value Above the CRQL table (Above CRQL table) is a subset of the complete data set. Only constituents that were detected above the CRQL in at least one sample collected for the project during the current reporting period are reported in the Above CRQL table.

The first three column headings are as follows:

- Well name--Well from which sample was collected.
- Collection date--Date sample was collected.
- Sample number--Unique number assigned to a well sample.

The remaining columns contain analytical results and qualifiers for the constituent. The structure of the column header is as follows.

Constituent short name
Method code/reporting units
CRQL/DWS (suffix).

The Summary table (Section 5.3A.1.2) shows the relationship between the full constituent name and the short name. The analytical method code is defined in Table 5.3A-1. Abbreviations used for reporting units are listed in Section 5.3A.1.5. On the third line, a period appears in place of the CRQL or DWS if a value does not exist. The one-letter suffix that may be added to the DWS identifies the regulation associated with the standard and is described in Section 5.3A.1.5.

Analysis results are displayed with two digits to the right of the decimal point. This is a consequence of the generating software and does not reflect the accuracy of the results. The laboratories normally report the result with three significant digits. Radionuclide values may be negative because the laboratory subtracts a background reading from the measured result. The letter, or group of letters, that may follow the result are data qualifiers and flags. A complete explanation of what each flag means is provided in Section 5.3A.1.5.

5.3A.1.4 Contamination Indicator Parameters

The CIP table has a format similar to the Above CRQL table (Section 5.3A.1.3) but includes only data for pH, specific conductance, total organic carbon, and total organic halogen. All results for these parameters, whether above CRQL or not, are listed in the CIP table. The analysis method code is not part of the column header in this report.

Table 5.3A-1. Analysis Method Code Definitions.

Method code	Method name
16	SW-846 8240[a]
17	SW-846 8080[a]
19	SW-846 8270[a]
25	SW-846 8010/8020[a]
29	SW-846 8140[a]
30	SW-846 8040[a]
34	SW-846 6010[a]
36	ASTM D-1385[b]
40	SW-846 7421[a]
41	SW-846 7470[a]
42	SW-846 7841[a]
43	SW-846 7060[a]
48	SW-846 7740[a]
49	SW-846 8150[a]
51	SW-846 8280[a]
52	ASTM D-1067-A
54	ASTM D-1426-D
56	SW-846 9010[a]
62	In-house ion chromatography
63	SW-846 9030[a]
65	Standard Methods #209B[c]
67	SW-846 9020[a]
69	SW-846 9131[a]
73	ASTM D-1125-A
93	Field probe, pH
94	Field probe, conductivity
122	SW-846 9060[a]
124	ASTM D-4327-88
125	ASTM D-1293
126	Standard Methods #214A[c]
127	ASTM D-2579-A
130	EPA Method 300.0[d]
135	SW-846 9310, Alpha[a]
136	SW-846 9310, Beta[a]
137	SW-846 9315, Radium[a]
139	ITAS I-129 Low level
140	ITAS Gamma scan
141	ITAS Sr-90
142	ITAS H-3
143	ITAS Tc-99
144	SW-846 9132[a]
145	ITAS Gross U
146	ITAS Isotopic Pu
147	ITAS Am-241
148	ITAS Isotopic U
168	USEPA HACH COD[a]
357	EPA 600, 310.2

[a](EPA 1986).
[b](ASTM 1991).
[c](EPA 1979).
[d](APHA 1989).

5.3A.1.5 Codes and Abbreviations

Abbreviations--The abbreviations used in the data tables are as follows:

COL	coliform colonies per 100 milliliters
CRQL	contractually required quantitation limit
DWS	drinking water standard
ft	feet
msl	mean sea level
NTU	nephelometric turbidity unit
pCi/L	picocuries per liter
ppb	parts per billion
ppm	parts per million
µmho	micromhos per centimeter.

Agencies and suffixes--Agency codes and DWS suffixes identify the regulatory origin of the standard of the DWS. Agency codes are used in the Summary table, and DWS suffixes are used in the Above CRQL and CIP tables. The codes are defined as follows:

Agency	Suffix	Regulatory basis
EPA	None	Maximum contaminant levels in 40 *Code of Federal Regulations* (CFR) 141, "National Primary Drinking Water Regulations;" not including subsequent changes made through the Federal Register.
EPAS	s	Secondary maximum contaminant levels in 40 CFR 143, "National Secondary Drinking Water Regulations."

Data qualifiers and flags--Data qualifiers and flags used in the Above CRQL and CIP tables are assigned by the laboratory and by the Westinghouse Hanford Company Quality Control (QC) team, respectively. Qualifiers reflect conditions occurring in the laboratory relating to the analytical procedure. Flags serve a wider function of alerting the data user to the limitations of the reported value. Qualifiers and flags can be appended to each other to form a string of letters when several factors apply to a result. The qualifiers and flags used are as follows:

Laboratory qualifiers:

- B - Blank associated with analyte is contaminated
- D - Analyzed sample is diluted
- E - Concentration is out of instrument calibration range
- J - Concentration is estimated
- L - Concentration is below the CRQL but above the MDL
- U - Concentration is below the indicated value.

QC Flags:

D - Result associated with a documented laboratory nonconformance
H - Laboratory holding time exceeded
P - Potential problem; see text associated with table
Q - Result associated with suspect QC data
F - Suspect data currently under review
+ - Suspect water level data currently under review
* - CRQL is greater than DWS, so exceedance of DWS is undetermined.

Analysis method codes--Analysis method codes are used as an abbreviation for the laboratory method used to perform an analysis. A complete listing of the analysis method codes used in the Summary and Above CRQL tables is shown in Table 5.3A-1.

DWSs--DWSs are used in all of the chemistry tables to provide a standard with which to compare sample results.

5.3A.2 REFERENCES

40 CFR 141, "National Primary Drinking Water Regulations," *Code of Federal Regulations*, as amended.

40 CFR 143, "National Secondary Drinking Water Regulations," *Code of Federal Regulations*, as amended.

APHA, 1989, *Standard Methods for Evaluation of Water and Wastewater*, 17th ed., American Public Health Association, Washington, D.C.

ASTM, 1991, *Annual Book of ASTM Standards*, Vol. 11.01, Water and Environmental Technology, Philadelphia, Pennsylvania.

EPA, 1979, *Methods for Chemical Analysis of Water and Waste*, EPA-600/4-79-020, U.S. Environmental Protection Agency, Cincinnati, Ohio.

EPA, 1986, *Test Methods for Evaluating Solid Waste*, SW-846, Third Edition, U.S. Environmental Protection Agency, Washington, D.C.

Constituent List and Summary of Results for the Solid Waste Landfill Data for Reporting Period October 1, 1992 through September 30, 1993. (sheet 1 of 2)

CONTAMINATION INDICATOR PARAMETERS

Constituent Name Short	(Method)	Full	Units	Lab CRQL	DWS Limit	DWS Agency	Number of Samples Total	>CRQL	>DWS
CONDUCT	94	Conductivity, field	µmho	1			120	120	
CONDUCT	73	Conductivity, lab	µmho				40	40	
TOC		Total Organic Carbon	ppb	1000			128	0	
TOXLDL		Total Organic Halogen	ppb	10			125	66	
PH	93	pH, field		.1	6.5-8.5	EPAS	120	120	0
PH	125	pH, lab			6.5-8.5	EPAS	40	40	0

DRINKING WATER PARAMETERS

Constituent Name Short	(Method)	Full	Units	Lab CRQL	DWS Limit	DWS Agency	Number of Samples Total	>CRQL	>DWS
FBARIUM		Barium, filtered	ppb	20	1000	EPA	32	32	0
FCADMIU		Cadmium, filtered	ppb	10	10	EPA	32	0	0
FCHROMI		Chromium, filtered	ppb	20	50	EPA	32	0	0
COLIFORM		Coliforms	COL		1	EPA	33	0	0
FLUORID		Fluoride	ppb	100	4000	EPA	28	28	0
ALPHA		Gross alpha	pCi/L	4	15	EPA	32	24	0
BETA		Gross beta	pCi/L	8	50	EPA	32	32	0
NITRATE		Nitrate	ppb	200	45000	EPA	28	28	0
FSILVER		Silver, filtered	ppb	20	50	EPA	32	0	0
TURBID		Turbidity	NTU	.1	1	EPA	31	30	13

GROUNDWATER QUALITY PARAMETERS

Constituent Name Short	(Method)	Full	Units	Lab CRQL	DWS Limit	DWS Agency	Number of Samples Total	>CRQL	>DWS
CHLORID		Chloride	ppb	200	250000	EPAS	28	28	0
FIRON		Iron, filtered	ppb	20	300	EPAS	32	25	0
FMANGAN		Manganese, filtered	ppb	10	50	EPAS	32	0	0
FSODIUM		Sodium, filtered	ppb	300			32	32	
SULFATE		Sulfate	ppb	500	250000	EPAS	28	28	0

SITE SPECIFIC AND OTHER CONSTITUENTS

Constituent Name Short	(Method)	Full	Units	Lab CRQL	DWS Limit	DWS Agency	Number of Samples Total	>CRQL	>DWS
1,1,1-T		1,1,1-Trichloroethane	ppb	.5			24	20	
1,1,2-T		1,1,2-Trichloroethane	ppb	.5			24	0	
1,1-DIC		1,1-Dichloroethane	ppb	1			24	14	
1,2-DIC		1,2-Dichloroethane	ppb	.5			24	1	
14-dben		1,4-Dichlorobenzene	ppb	2			24	0	
ALKALIN	357	Alkalinity	ppm	50			5	5	
ALKALIN	52	Alkalinity	ppm	50			24	24	
FALUMIN		Aluminum	ppb	200			16	0	
AMMONIU	129	Ammonium ion	ppb	100			9	0	
AMMONIU	54	Ammonium ion	ppb	100			25	1	
FANTIMO		Antimony, filtered	ppb	200			32	1	
BENZENE		Benzene	ppb	2			24	0	
FBERYLL		Beryllium, filtered	ppb	3			32	0	
BROMIDE		Bromide	ppb	500			28	0	
FCALCIU		Calcium, filtered	ppb	100			32	32	
TETRANE		Carbon tetrachloride	ppb	1			24	0	

Constituent List and Summary of Results for the Solid Waste Landfill Data for Reporting Period October 1, 1992 through September 30, 1993. (sheet 2 of 2)

SITE SPECIFIC AND OTHER CONSTITUENTS

Constituent Name				Lab	DWS		Number of Samples		
Short	(Method)	Full	Units	CRQL	Limit	Agency	Total	>CRQL	>DWS
COD	168	Chemical Oxygen Demand	ppm	3			17	0	
COD	356	Chemical Oxygen Demand	ppm	3			9	0	
CHLFORM		Chloroform	ppb	.5	100	EPA	24	0	0
FCOBALT		Cobalt, filtered	ppb	20			32	0	
FCOPPER		Copper, filtered	ppb	20	1000	EPAS	32	0	0
ETHBENZ		Ethylbenzene	ppb	2			24	0	
FMAGNES		Magnesium, filtered	ppb	100			32	32	
METHYCH		Methylene chloride	ppb	5			24	0	
FNICKEL		Nickel, filtered	ppb	30			32	0	
NITRITE		Nitrite	ppb	200			28	0	
PHOSPHA		Phosphate	ppb	400			28	0	
FPOTASS		Potassium, filtered	ppb	300			32	32	
TMP_C		Temperature, field	DegC	.1			53	53	
PERCENE		Tetrachloroethene	ppb	.5			24	22	
FTIN		Tin, filtered	ppb	100			32	0	
TOLUENE		Toluene	ppb	2			24	0	
TC		Total Carbon	ppb	2000			32	32	
TRICENE		Trichloroethene	ppb	1			24	16	
TRITIUM		Tritium	pCi/L	500	20000	EPA	32	32	29
FVANADI		Vanadium, filtered	ppb	30			32	0	
VINYIDE		Vinyl chloride	ppb	2	2	EPA	24	0	0
XYLENE		Xylenes (total)	ppb	5			24	0	
FZINC		Zinc, filtered	ppb	10			32	4	
CIS12DE		cis-1,2-Dichloroethylene	ppb	1			24	0	
TRANDCE		trans-1,2-Dichloroethylene	ppb	1			16	0	

Constituents with at Least One Value Above the CRQL for the Solid Waste Landfill
Data for Reporting Period October 1, 1992 through September 30, 1993.
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Well Name	Collection Date	Sample Number	1,1,1-T 25/ppb .5/.	1,1-DIC 25/ppb 1/.	1,2-DIC 25/ppb .5/.	ALKALIN 357/ppm 50/.
699-23-34A	12/17/92	B07SZ1	23.00	3.20	.50 U	
699-23-34A	3/23/93	B08B55	27.00	3.70	.50 U	
699-23-34A	7/02/93	B08P70	26.00	3.60	.14 U	
699-23-34A	9/29/93	B09716				280.00 B
699-24-33	12/17/92	B07SZ6	7.90	1.30	.50 U	
699-24-33	3/23/93	B08B60	7.20	1.10	.50 U	
699-24-33	7/02/93	B08P75	6.60	.89 L	.14 U	
699-24-33	9/29/93	B09721				280.00 B
699-24-34A	12/18/92	B07T01	18.00	2.60	.50 U	
699-24-34A	3/23/93	B08B65	16.00	2.30	.50 U	
699-24-34A	7/02/93	B08P80	16.00	2.10	.63	
699-24-34A	9/30/93	B09726				270.00 B
699-24-34A	9/30/93	B09727				270.00 B
699-24-34B	12/18/92	B07T11	11.00	2.00	.50 U	
699-24-34B	3/23/93	B08B70	10.00	1.70	.50 U	
699-24-34B	7/07/93	B08P85	9.40	1.60	.14 U	
699-24-34C	12/18/92	B07T16	11.00	2.30	.50 U	
699-24-34C	3/24/93	B08B76	.50 UF	2.30	.50 U	
699-24-34C	7/07/93	B08P90	8.00	1.60	.14 U	
699-24-35	12/18/92	B07T21	4.20	1.00 U	.50 U	
699-24-35	3/24/93	B08B81	.50 U	1.00 U	.50 U	
699-24-35	3/24/93	B08B82	.50 U	1.00 U	.50 U	
699-24-35	7/07/93	B08P95	2.90	.34 U	.14 U	
699-25-34C	12/17/92	B07T26	4.10	1.00 U	.50 U	
699-25-34C	3/24/93	B08B91	.50 UF	1.00 U	.50 U	
699-25-34C	7/01/93	B08P80	3.40	.35 L	.14 U	
699-25-34C	9/16/93	B09751				220.00 B
699-26-35A	12/17/92	B07T31	1.40	1.00 U	.50 U	
699-26-35A	7/01/93	B08P85	1.40	.34 U	.14 U	

Well Name	Collection Date	Sample Number	ALKALIN 52/ppm 50/.	AMMONIU 54/ppb 100/.	FANTIMO 34/ppb 200/.	FBARIUM 34/ppb 20/1000
699-23-34A	12/17/92	B07SZ1	270.00	100.00 U		
699-23-34A	12/17/92	B07SZ5			200.00 U	90.00
699-23-34A	3/23/93	B08B55	280.00	100.00 U		
699-23-34A	3/23/93	B08B59			200.00 U	92.00
699-23-34A	7/02/93	B08P70	290.00	40.00 L		
699-23-34A	7/02/93	B08P74			69.40 U	91.00
699-23-34A	9/29/93	B09720			69.40 U	97.00
699-24-33	12/17/92	B07SZ6	260.00	100.00 U		
699-24-33	12/17/92	B07T00			900.00	70.00
699-24-33	3/23/93	B08B60	260.00	100.00 U		
699-24-33	3/23/93	B08B64			200.00 U	70.00
699-24-33	7/02/93	B08P75	270.00	40.00 L		
699-24-33	7/02/93	B08P79			69.40 U	70.00
699-24-33	9/29/93	B09725			69.40 U	79.00
699-24-34A	12/18/92	B07T01	250.00	100.00 U		
699-24-34A	12/18/92	B07T09			200.00 U	70.00
699-24-34A	3/23/93	B08B65	250.00	100.00 U		
699-24-34A	3/23/93	B08B69			200.00 U	72.00
699-24-34A	7/02/93	B08P80	260.00	50.00 L		
699-24-34A	7/02/93	B08P84			69.40 U	73.00
699-24-34A	9/30/93	B09734			69.40 U	79.00

Constituents with at Least One Value Above the CRQL for the Solid Waste Landfill
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Well Name	Collection Date	Sample Number	ALKALIN 52/ppm 50/.	AMMONIU 54/ppb 100/.	FANTIMO 34/ppb 200/.	FBARIUM 34/ppb 20/1000
699-24-34A	9/30/93	B09735			69.40 U	79.00
699-24-34B	12/18/92	B07T11	250.00	100.00 U		
699-24-34B	12/18/92	B07T15			200.00 U	80.00
699-24-34B	3/23/93	B08B70	250.00	100.00 U		
699-24-34B	3/23/93	B08B75			200.00 U	72.00
699-24-34B	7/07/93	B08P85	260.00	38.50 U		
699-24-34B	7/07/93	B08P89			69.40 U	77.00
699-24-34B	9/20/93	B09740			69.40 U	72.00
699-24-34C	12/18/92	B07T16	320.00	100.00 U		
699-24-34C	12/18/92	B07T20			200.00 U	70.00
699-24-34C	3/24/93	B08B76	300.00	100.00 U		
699-24-34C	3/24/93	B08B80			200.00 U	70.00
699-24-34C	7/07/93	B08P90	320.00	38.50 U		
699-24-34C	7/07/93	B08P94			69.40 U	71.00
699-24-34C	9/20/93	B09745			69.40 U	65.00
699-24-35	12/18/92	B07T21	180.00	100.00 U		
699-24-35	12/18/92	B07T25			200.00 U	60.00
699-24-35	3/24/93	B08B81	190.00	100.00 U		
699-24-35	3/24/93	B08B82	190.00	100.00 U		
699-24-35	3/24/93	B08B89			200.00 U	60.00
699-24-35	3/24/93	B08B90			200.00 U	50.00
699-24-35	7/07/93	B08P95	200.00	40.00 L		
699-24-35	7/07/93	B08P99			69.40 U	62.00
699-24-35	9/20/93	B09750			69.40 U	55.00
699-25-34C	12/17/92	B07T26	200.00	100.00 U		
699-25-34C	12/17/92	B07T30			200.00 U	50.00
699-25-34C	3/24/93	B08B91	190.00	100.00 U		
699-25-34C	3/24/93	B08B95			200.00 U	50.00
699-25-34C	7/01/93	B08P80	210.00	38.50 U		
699-25-34C	7/01/93	B08P84			69.40 U	52.00
699-25-34C	9/16/93	B09755			69.40 U	56.00
699-26-35A	12/17/92	B07T31	140.00	100.00		
699-26-35A	12/17/92	B07T35			200.00 U	30.00
699-26-35A	3/24/93	B08B71		100.00 U		
699-26-35A	7/01/93	B08P85	150.00	50.00 L		
699-26-35A	7/01/93	B08P89			69.40 U	35.00

Well Name	Collection Date	Sample Number	FCALCIU 34/ppb 100/.	CHLORID 124/ppb 200/250000s	FLUORID 124/ppb 100/4000	ALPHA 135/pCi/L ./15
699-23-34A	12/17/92	B07S21		7100.00	400.00	7.48
699-23-34A	12/17/92	B07S25	85000.00			
699-23-34A	3/23/93	B08B55		7000.00 H	400.00 H	3.53 U
699-23-34A	3/23/93	B08B59	84000.00 Q			
699-23-34A	7/02/93	B08P70		7000.00	1000.00	3.11
699-23-34A	7/02/93	B08P74	85000.00			
699-23-34A	9/29/93	B09716				5.02
699-23-34A	9/29/93	B09720	86000.00			
699-24-33	12/17/92	B07S26		7400.00	400.00	2.09 U
699-24-33	12/17/92	B07T00	82000.00			
699-24-33	3/23/93	B08B60		7300.00 H	300.00 H	5.82
699-24-33	3/23/93	B08B64	79000.00 Q			
699-24-33	7/02/93	B08P75		7400.00	800.00	3.06
699-24-33	7/02/93	B08P79	79000.00			

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Well Name	Collection Date	Sample Number	FCALCIU 34/ppb 100/.	CHLORID 124/ppb 200/250000s	FLUORID 124/ppb 100/4000	ALPHA 135/pCi/L ./15
699-24-33	9/29/93	B09721				3.76
699-24-33	9/29/93	B09725	85000.00			
699-24-34A	12/18/92	B07T01		7300.00	400.00	3.69 U
699-24-34A	12/18/92	B07T09	75000.00			
699-24-34A	3/23/93	B08B65		7200.00 H	400.00 H	4.29
699-24-34A	3/23/93	B08B69	74000.00 Q			
699-24-34A	7/02/93	B08P80		7200.00	900.00	4.99
699-24-34A	7/02/93	B08P84	76000.00			
699-24-34A	9/30/93	B09726				4.53
699-24-34A	9/30/93	B09727				4.55
699-24-34A	9/30/93	B09734	77000.00			
699-24-34A	9/30/93	B09735	77000.00			
699-24-34B	12/18/92	B07T11		7500.00	400.00	4.22
699-24-34B	12/18/92	B07T15	81000.00			
699-24-34B	3/23/93	B08B70		7400.00 H	400.00 H	3.84 U
699-24-34B	3/23/93	B08B75	76000.00 Q			
699-24-34B	7/07/93	B08P85		7200.00	900.00	5.23
699-24-34B	7/07/93	B08P89	80000.00			
699-24-34B	9/20/93	B09736		7000.00	400.00	4.78
699-24-34B	9/20/93	B09740	78000.00			
699-24-34C	12/18/92	B07T16		7800.00	400.00	2.65 U
699-24-34C	12/18/92	B07T20	96000.00			
699-24-34C	3/24/93	B08B76		7400.00	700.00	2.89 U
699-24-34C	3/24/93	B08B80	96000.00			
699-24-34C	7/07/93	B08P90		7600.00	900.00	4.78
699-24-34C	7/07/93	B08P94	100000.00			
699-24-34C	9/20/93	B09741		7400.00	400.00	3.38
699-24-34C	9/20/93	B09745	95000.00			
699-24-35	12/18/92	B07T21		6900.00	400.00	4.17
699-24-35	12/18/92	B07T25	57000.00			
699-24-35	3/24/93	B08B81		6600.00	600.00	4.35
699-24-35	3/24/93	B08B82		6600.00	600.00	4.38
699-24-35	3/24/93	B08B89	58000.00			
699-24-35	3/24/93	B08B90	55000.00			
699-24-35	7/07/93	B08P95		6600.00	700.00	5.21
699-24-35	7/07/93	B08P99	60000.00			
699-24-35	9/20/93	B09746		6400.00	400.00	3.97
699-24-35	9/20/93	B09750	57000.00			
699-25-34C	12/17/92	B07T26		7100.00	400.00	3.74 U
699-25-34C	12/17/92	B07T30	62000.00			
699-25-34C	3/24/93	B08B91		7100.00	600.00	4.13
699-25-34C	3/24/93	B08B95	58000.00			
699-25-34C	7/01/93	B08P80		7300.00	700.00	4.19
699-25-34C	7/01/93	B08P84	62000.00			
699-25-34C	9/16/93	B09751		6800.00	500.00	4.12
699-25-34C	9/16/93	B09755	69000.00			
699-26-35A	12/17/92	B07T31		6800.00	500.00	3.71 U
699-26-35A	12/17/92	B07T35	43000.00			
699-26-35A	7/01/93	B08P85		6900.00	700.00	4.66
699-26-35A	7/01/93	B08P89	44000.00			

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Well Name	Collection Date	Sample Number	BETA 136/pCi/L ./50	FIRON 34/ppb 20/300s	FMAGNES 34/ppb 100/.	NITRATE 124/ppb 200/45000
699-23-34A	12/17/92	B07SZ1	9.75			14000.00
699-23-34A	12/17/92	B07SZ5		20.00 U	18000.00	
699-23-34A	3/23/93	B08B55	11.50			13000.00 H
699-23-34A	3/23/93	B08B59		110.00	18000.00	
699-23-34A	7/02/93	B08P70	12.50			13000.00
699-23-34A	7/02/93	B08P74		53.00	18000.00	
699-23-34A	9/29/93	B09716	11.30			
699-23-34A	9/29/93	B09720		110.00	20000.00	
699-24-33	12/17/92	B07S26	17.30			29000.00
699-24-33	12/17/92	B07T00		30.00	18000.00	
699-24-33	3/23/93	B08B60	12.00			27000.00 H
699-24-33	3/23/93	B08B64		32.00	18000.00	
699-24-33	7/02/93	B08P75	16.90			27000.00
699-24-33	7/02/93	B08P79		10.30 U	18000.00	
699-24-33	9/29/93	B09721	13.30			
699-24-33	9/29/93	B09725		10.30 U	20000.00	
699-24-34A	12/18/92	B07T01	13.10			16000.00
699-24-34A	12/18/92	B07T09		70.00	17000.00	
699-24-34A	3/23/93	B08B65	11.00			15000.00 H
699-24-34A	3/23/93	B08B69		36.00	17000.00	
699-24-34A	7/02/93	B08P80	12.80			16000.00
699-24-34A	7/02/93	B08P84		68.00	17000.00	
699-24-34A	9/30/93	B09726	15.20			
699-24-34A	9/30/93	B09727	12.80			
699-24-34A	9/30/93	B09734		68.00	19000.00	
699-24-34A	9/30/93	B09735		71.00	18000.00	
699-24-34B	12/18/92	B07T11	13.50			21000.00
699-24-34B	12/18/92	B07T15		40.00	18000.00	
699-24-34B	3/23/93	B08B70	13.50			20000.00 H
699-24-34B	3/23/93	B08B75		35.00	17000.00	
699-24-34B	7/07/93	B08P85	15.30			17000.00
699-24-34B	7/07/93	B08P89		50.00	18000.00	
699-24-34B	9/20/93	B09736	10.30			17000.00 D
699-24-34B	9/20/93	B09740		35.00	17000.00	
699-24-34C	12/18/92	B07T16	16.00			29000.00
699-24-34C	12/18/92	B07T20		60.00	19000.00	
699-24-34C	3/24/93	B08B76	13.90			28000.00
699-24-34C	3/24/93	B08B80		50.00	19000.00	
699-24-34C	7/07/93	B08P90	12.30			27000.00
699-24-34C	7/07/93	B08P94		44.00	20000.00	
699-24-34C	9/20/93	B09741	13.70			25000.00 D
699-24-34C	9/20/93	B09745		67.00	19000.00	
699-24-35	12/18/92	B07T21	9.86			13000.00
699-24-35	12/18/92	B07T25		40.00	14000.00	
699-24-35	3/24/93	B08B81	12.60			14000.00
699-24-35	3/24/93	B08B82	12.00			13000.00
699-24-35	3/24/93	B08B89		20.00	13000.00	
699-24-35	3/24/93	B08B90		20.00	13000.00	
699-24-35	7/07/93	B08P95	10.10			13000.00
699-24-35	7/07/93	B08P99		42.00	14000.00	
699-24-35	9/20/93	B09746	9.37			12000.00 D
699-24-35	9/20/93	B09750		31.00	13000.00	

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Well Name	Collection Date	Sample Number	BETA 136/pCi/L ./50	FIRON 34/ppb 20/300s	FMAGNES 34/ppb 100/.	NITRATE 124/ppb 200/45000
699-25-34C	12/17/92	B07T26	14.50			31000.00
699-25-34C	12/17/92	B07T30		20.00 U	16000.00	
699-25-34C	3/24/93	B08B91	15.80			30000.00
699-25-34C	3/24/93	B08B95		20.00 U	14000.00	
699-25-34C	7/01/93	B08P80	17.90			29000.00
699-25-34C	7/01/93	B08P84		40.00	16000.00	
699-25-34C	9/16/93	B09751	15.00			26000.00 D
699-25-34C	9/16/93	B09755		61.00	16000.00	
699-26-35A	12/17/92	B07T31	11.90			30000.00
699-26-35A	12/17/92	B07T35		20.00 U	12000.00	
699-26-35A	7/01/93	B08P85	15.20			28000.00
699-26-35A	7/01/93	B08P89		10.30 U	12000.00	

Well Name	Collection Date	Sample Number	FPOTASS 34/ppb 1000/.	FSODIUM 34/ppb 300/.	SULFATE 124/ppb 500/250000s	TMP_C 170/DegC .1/.
699-23-34A	12/17/92	B07SZ1			48000.00	17.80
699-23-34A	12/17/92	B07SZ5	8000.00	23000.00		
699-23-34A	3/23/93	B08B55			46000.00 H	18.40
699-23-34A	3/23/93	B08B59	7900.00	23000.00		
699-23-34A	7/02/93	B08P70			48000.00	18.50
699-23-34A	7/02/93	B08P74	8100.00	22000.00		
699-23-34A	9/29/93	B09716				19.20
699-23-34A	9/29/93	B09720	7500.00	23000.00		
699-24-33	12/17/92	B07SZ6			45000.00	19.90
699-24-33	12/17/92	B07T00	7900.00	24000.00		
699-24-33	3/23/93	B08B60			43000.00 H	20.10
699-24-33	3/23/93	B08B64	7800.00	23000.00		
699-24-33	7/02/93	B08P75			44000.00	19.90
699-24-33	7/02/93	B08P79	7500.00	22000.00		
699-24-33	9/29/93	B09721				19.60
699-24-33	9/29/93	B09725	6900.00	24000.00		
699-24-34A	12/18/92	B07T01			48000.00	17.80
699-24-34A	12/18/92	B07T09	7800.00	23000.00		
699-24-34A	3/23/93	B08B65			45000.00 H	18.50
699-24-34A	3/23/93	B08B69	7600.00	22000.00		
699-24-34A	7/02/93	B08P80			49000.00	18.80
699-24-34A	7/02/93	B08P84	7600.00	22000.00		
699-24-34A	9/30/93	B09726				17.90
699-24-34A	9/30/93	B09727				17.90
699-24-34A	9/30/93	B09728				17.90
699-24-34A	9/30/93	B09729				17.90
699-24-34A	9/30/93	B09734	7000.00	23000.00		
699-24-34A	9/30/93	B09735	6600.00	23000.00		
699-24-34B	12/18/92	B07T11			47000.00	17.60
699-24-34B	12/18/92	B07T15	7600.00	24000.00		
699-24-34B	3/23/93	B08B70			45000.00 H	18.80
699-24-34B	3/23/93	B08B75	7600.00	22000.00		
699-24-34B	7/07/93	B08P85			41000.00	18.70
699-24-34B	7/07/93	B08P89	7500.00	23000.00		

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Well Name	Collection Date	Sample Number	FPOTASS 34/ppb 1000/.	FSODIUM 34/ppb 300/.	SULFATE 124/ppb 500/250000s	TMP_C 170/DegC .1/.
699-24-34B	9/20/93	B09736			46000.00 D	18.50
699-24-34B	9/20/93	B09737				18.50
699-24-34B	9/20/93	B09738				18.50
699-24-34B	9/20/93	B09739				18.50
699-24-34B	9/20/93	B09740	7600.00	24000.00		
699-24-34C	12/18/92	B07T16			44000.00	18.40
699-24-34C	12/18/92	B07T20	7900.00	24000.00		
699-24-34C	3/24/93	B08B76			43000.00	18.20
699-24-34C	3/24/93	B08B80	9200.00	24000.00		
699-24-34C	7/07/93	B08P90			43000.00	19.10
699-24-34C	7/07/93	B08P94	8300.00	24000.00		
699-24-34C	9/20/93	B09741			43000.00 D	18.10
699-24-34C	9/20/93	B09742				18.10
699-24-34C	9/20/93	B09743				18.10
699-24-34C	9/20/93	B09744				18.10
699-24-34C	9/20/93	B09745	7800.00	22000.00		
699-24-35	12/18/92	B07T21			48000.00	17.20
699-24-35	12/18/92	B07T22				17.40
699-24-35	12/18/92	B07T23				17.70
699-24-35	12/18/92	B07T25	7500.00	23000.00		
699-24-35	3/24/93	B08B81			46000.00	18.00
699-24-35	3/24/93	B08B82			48000.00	
699-24-35	3/24/93	B08B89	7800.00	23000.00		
699-24-35	3/24/93	B08B90	7500.00	21000.00		
699-24-35	7/07/93	B08P95			46000.00	
699-24-35	7/07/93	B08P98				18.20
699-24-35	7/07/93	B08P99	7500.00	23000.00		
699-24-35	9/20/93	B09746			45000.00 D	18.00
699-24-35	9/20/93	B09747				18.00
699-24-35	9/20/93	B09748				18.10
699-24-35	9/20/93	B09749				18.10
699-24-35	9/20/93	B09750	7300.00	22000.00		
699-25-34C	12/17/92	B07T26			45000.00	19.40
699-25-34C	12/17/92	B07T30	7200.00	25000.00		
699-25-34C	3/24/93	B08B91			45000.00	18.80
699-25-34C	3/24/93	B08B95	7600.00	24000.00		
699-25-34C	7/01/93	B08PB0			48000.00	19.70
699-25-34C	7/01/93	B08PB1				19.70
699-25-34C	7/01/93	B08PB2				19.70
699-25-34C	7/01/93	B08PB3				19.60
699-25-34C	7/01/93	B08PB4	7100.00	27000.00		
699-25-34C	9/16/93	B09751			39000.00 D	19.90
699-25-34C	9/16/93	B09752				19.80
699-25-34C	9/16/93	B09753				19.80
699-25-34C	9/16/93	B09754				19.80
699-25-34C	9/16/93	B09755	6900.00	25000.00		
699-26-35A	12/17/92	B07T31			41000.00	19.80
699-26-35A	12/17/92	B07T35	6000.00	22000.00		
699-26-35A	7/01/93	B08PB5			40000.00	19.40
699-26-35A	7/01/93	B08PB6				19.40
699-26-35A	7/01/93	B08PB7				19.40
699-26-35A	7/01/93	B08PB8				19.40
699-26-35A	7/01/93	B08PB9	6200.00	22000.00		

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Well Name	Collection Date	Sample Number	PERCENE 25/ppb .5/.	TC 127/ppb 2000/.	TRICENE 25/ppb 1/.	TRITIUM 142/pCi/L ./20000
699-23-34A	12/17/92	B07SZ1	2.70	66000.00	3.20	31500.00
699-23-34A	3/23/93	B08B55	5.90	68000.00	3.40	24900.00
699-23-34A	7/02/93	B08P70	4.40	72000.00	3.00	20800.00
699-23-34A	9/29/93	B09716		72000.00 B		19300.00
699-24-33	12/17/92	B07SZ6	2.70	57000.00	1.70	231000.00
699-24-33	3/23/93	B08B60	3.90	61000.00	1.30	211000.00
699-24-33	7/02/93	B08P75	3.10	65000.00	1.20	181000.00
699-24-33	9/29/93	B09721		67000.00 B		175000.00
699-24-34A	12/18/92	B07T01	3.40	60000.00	2.50	59900.00
699-24-34A	3/23/93	B08B65	5.60	57000.00	2.30	54300.00
699-24-34A	7/02/93	B08P80	4.10	64000.00	2.60	44800.00
699-24-34A	9/30/93	B09726		65000.00 B		39500.00
699-24-34A	9/30/93	B09727		65000.00 B		39600.00
699-24-34B	12/18/92	B07T11	3.20	61000.00	2.00	120000.00
699-24-34B	3/23/93	B08B70	5.50	61000.00	1.80	112000.00
699-24-34B	7/07/93	B08P85	4.20	74000.00	1.60	89600.00
699-24-34B	9/20/93	B09736		59000.00 B		77900.00
699-24-34C	12/18/92	B07T16	3.70	62000.00	2.00	228000.00
699-24-34C	3/24/93	B08B76	5.30	65000.00	1.90	212000.00
699-24-34C	7/07/93	B08P90	3.60	90000.00	1.20	196000.00
699-24-34C	9/20/93	B09741		70000.00 B		179000.00
699-24-35	12/18/92	B07T21	.50	44000.00	1.00 U	27000.00
699-24-35	3/24/93	B08B81	1.20	42000.00	1.00 U	25200.00
699-24-35	3/24/93	B08B82	1.20	45000.00	1.00 U	25500.00
699-24-35	7/07/93	B08P95	.77	53000.00	.23 L	19700.00
699-24-35	9/20/93	B09746		49000.00 B		15800.00
699-25-34C	12/17/92	B07T26	1.00	42000.00	1.20	265000.00
699-25-34C	3/24/93	B08B91	1.40	42000.00	1.00 U	252000.00
699-25-34C	7/01/93	B08PB0	1.20	48000.00	.75 L	225000.00
699-25-34C	9/16/93	B09751		55000.00 B		226000.00
699-26-35A	12/17/92	B07T31	.50 U	31000.00	1.00 U	271000.00
699-26-35A	7/01/93	B08PB5	.33 L	36000.00	.19 L	235000.00

Well Name	Collection Date	Sample Number	TURBID 126/NTU .1/1	FZINC 34/ppb 10/.
699-23-34A	12/17/92	B07SZ1	.20	
699-23-34A	12/17/92	B07SZ5		10.00 U
699-23-34A	3/23/93	B08B55	.40	
699-23-34A	3/23/93	B08B59		10.00 U
699-23-34A	7/02/93	B08P70	.90	
699-23-34A	7/02/93	B08P74		3.44 U
699-23-34A	9/29/93	B09716	1.00	
699-23-34A	9/29/93	B09720		3.44 U
699-24-33	12/17/92	B07SZ6	.60	
699-24-33	12/17/92	B07T00		30.00
699-24-33	3/23/93	B08B60	.10 U	
699-24-33	3/23/93	B08B64		10.00 U
699-24-33	7/02/93	B08P75	.20	

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Well Name	Collection Date	Sample Number	TURBID 126/NTU .1/1	FZINC 34/ppb 10/.
699-24-33	7/02/93	B08P79		3.44 U
699-24-33	9/29/93	B09721	.80	
699-24-33	9/29/93	B09725		3.44 U
699-24-34A	12/18/92	B07T01	.40	
699-24-34A	12/18/92	B07T09		10.00 U
699-24-34A	3/23/93	B08B65	.80	
699-24-34A	3/23/93	B08B69		10.00 U
699-24-34A	7/02/93	B08P80	9.10	
699-24-34A	7/02/93	B08P84		3.44 U
699-24-34A	9/30/93	B09726	1.80	
699-24-34A	9/30/93	B09727	1.80	
699-24-34A	9/30/93	B09734		3.44 U
699-24-34A	9/30/93	B09735		3.44 U
699-24-34B	12/18/92	B07T11	.30	
699-24-34B	12/18/92	B07T15		10.00 U
699-24-34B	3/23/93	B08B70	.70	
699-24-34B	3/23/93	B08B75		10.00 U
699-24-34B	7/07/93	B08P85	2.50	
699-24-34B	7/07/93	B08P89		3.44 U
699-24-34B	9/20/93	B09736	9.40 Q	
699-24-34B	9/20/93	B09740		3.70 L
699-24-34C	12/18/92	B07T16	3.60	
699-24-34C	12/18/92	B07T20		20.00
699-24-34C	3/24/93	B08B76	2.20	
699-24-34C	3/24/93	B08B80		10.00 U
699-24-34C	7/07/93	B08P90	6.80	
699-24-34C	7/07/93	B08P94		15.00
699-24-34C	9/20/93	B09741	3.80 Q	
699-24-34C	9/20/93	B09745		18.00
699-24-35	12/18/92	B07T21	1.60	
699-24-35	12/18/92	B07T25		10.00 U
699-24-35	3/24/93	B08B81	.40	
699-24-35	3/24/93	B08B82	.40	
699-24-35	3/24/93	B08B89		10.00 U
699-24-35	3/24/93	B08B90		10.00 U
699-24-35	7/07/93	B08P95	2.40	
699-24-35	7/07/93	B08P99		8.00 L
699-24-35	9/20/93	B09746	.90 Q	
699-24-35	9/20/93	B09750		3.44 U
699-25-34C	12/17/92	B07T26	.30	
699-25-34C	12/17/92	B07T30		10.00 U
699-25-34C	3/24/93	B08B91	.50	
699-25-34C	3/24/93	B08B95		10.00 U
699-25-34C	7/01/93	B08P80	3.50	
699-25-34C	7/01/93	B08P84		3.44 U
699-25-34C	9/16/93	B09751	.80 Q	
699-25-34C	9/16/93	B09755		5.00 L
699-26-35A	12/17/92	B07T31	U	
699-26-35A	12/17/92	B07T35		10.00 U
699-26-35A	7/01/93	B08P85	2.00	
699-26-35A	7/01/93	B08P89		3.44 U

Contamination Indicator Parameters for the Solid Waste Landfill Data for Reporting Period October 1, 1992 through September 30, 1993. (sheet 1 of 3)

Well Name	Collection Date	Sample Number	COND FIELD µmho 1/700w	COND LAB µmho ./700w	pH FIELD .01/6.5-8.5s	pH LAB .01/6.5-8.5s	TOC ppb 1000/.	TOX ppb 10/.
699-23-34A	12/17/92	B07SZ1	618		6.86		1000 U	40.0 P
		B07SZ1						40.0 P
		B07SZ2	616		6.92		1000 U	40.0 P
		B07SZ2						40.0 P
		B07SZ3	616		6.88		1000 U	30.0 P
		B07SZ3						30.0 P
		B07SZ4	616		6.88		1000 U	
	3/23/93	B08B55	608		6.65		1000 U	50.0 PH
		B08B56	607		6.62		1000 U	40.0 PH
		B08B57	608		6.61		1000 U	30.0 PH
		B08B58	608		6.61		1000 U	40.0 PH
	7/02/93	B08P70	657	620	6.68	7.00	300 L	30.0 P
		B08P71	653		6.67		300 L	30.0 P
		B08P72	650		6.67		300 L	8.0 UP
		B08P73	645		6.63		200 L	8.0 UP
	9/29/93	B09716	645	640	6.63	7.40 H	200 U	40.0 P
		B09717	642	640	6.64	7.40 H	200 L	40.0 P
		B09718	640	640	6.64	7.40 H	200 U	40.0 P
		B09719	641	640	6.64	7.30 H	200 U	30.0 P
699-24-33	12/17/92	B07SZ6	640		7.10		1000 U	10.0 P
		B07SZ6						20.0 P
		B07SZ7	636		7.11		1000 U	10.0 P
		B07SZ7						10.0 P
		B07SZ8	633		7.12		1000 U	10.0 P
		B07SZ8						10.0 P
		B07SZ9	630		7.12		1000 U	10.0 P
		B07SZ9						10.0 P
	3/23/93	B08B60	470		7.14		1000 U	10.0 PH
		B08B61	477		7.12		1000 U	10.0 PH
		B08B62	465		7.11		1000 U	10.0 UPH
		B08B63	472		7.13		1000 U	10.0 UPH
	7/02/93	B08P75	641	610	6.83	7.30	200 L	8.0 UP
		B08P76	643		6.83		300 L	8.0 UP
		B08P77	642		6.83		300 L	8.0 UP
		B08P78	641		6.82		300 L	8.0 UP
	9/29/93	B09721	644	640	6.86	7.90 H	200 U	50.0 P
		B09722	642	650	6.84	7.60 H	200 U	10.0 P
		B09723	645	650	6.82	7.60 H	200 U	10.0 P
		B09724	643	650	6.82	7.60 H	200 L	8.0 UP
699-24-34A	12/18/92	B07T01	649		6.94		1000 U	20.0 PFH
		B07T01						30.0 PFH
		B07T03	649		6.92		1000 U	20.0 BPFH
		B07T03						20.0 PFH
		B07T05	647		6.89		1000 U	
		B07T07	643		6.86		1000 U	20.0 BPFH
		B07T07						10.0 PFH
	3/23/93	B08B65	528		6.70		1000 U	30.0 PH
		B08B66	532		6.69		1000 U	20.0 PH
		B08B67	531		6.69		1000 U	30.0 PH
		B08B68	529		6.69		1000 U	30.0 PH
	7/02/93	B08P80	600	580	6.68	7.00	300 L	8.0 UP
		B08P81	598		6.70		200 U	8.0 UP
		B08P82	596		6.69		200 U	8.0 UP
		B08P83	599		6.67		200 U	20.0 P

Contamination Indicator Parameters for the Solid Waste Landfill Data for Reporting Period October 1, 1992 through September 30, 1993. (sheet 2 of 3)

Well Name	Collection Date	Sample Number	COND FIELD µmho 1/700w	COND LAB µmho ./700w	pH FIELD .01/6.5-8.5s	pH LAB .01/6.5-8.5s	TOC ppb 1000/.	TOX ppb 10/.
699-24-34A	9/30/93	B09726	597	600	6.90	7.20	200 U	20.0 P
		B09727	595	600	6.88	7.30	200 U	20.0 P
		B09728	593	600	6.86	7.30	200 U	30.0 P
		B09729	591	580	6.82	7.20	200 U	20.0 P
		B09730		600		7.20	200 U	20.0 P
		B09731		600		7.40	200 U	30.0 P
		B09732		600		7.30	200 U	30.0 P
		B09733		600		7.30	200 U	30.0 P
699-24-34B	12/18/92	B07T11	667		7.13		1000 U	10.0 BPFH
		B07T11						10.0 PFH
		B07T12	660		7.08		1000 U	10.0 UPFH
		B07T12						10.0 PFH
		B07T13	633		7.06		1000 U	30.0 PFH
		B07T13						20.0 PFH
		B07T14	659		7.03		1000 U	20.0 PFH
		B07T14						20.0 PFH
	3/23/93	B08B70	573		6.87		1000 U	30.0 PH
		B08B72	575		6.74		1000 U	30.0 PH
		B08B73	575		6.80		1000 U	20.0 PH
		B08B74	574		6.85		1000 U	20.0 BPH
	7/07/93	B08P85	675	590	6.81	6.70	400 L	8.0 UP
		B08P86	674		6.81		300 L	10.0 P
		B08P87	673		6.80		300 L	8.0 UP
		B08P88	673		6.79		200 L	10.0 P
	9/20/93	B09736	607	610	7.00	7.40	300 L	8.0 UP
		B09737	606	610	6.98	7.30	300 L	10.0 P
		B09738	603	610	6.96	7.30	300 L	20.0 P
		B09739	606	610	6.94	7.30	300 L	8.0 UP
699-24-34C	12/18/92	B07T16	754		7.01		1000 U	20.0 PH
		B07T16						20.0 PH
		B07T17	750		6.99		1000 U	20.0 PH
		B07T17						20.0 PH
		B07T18	751		7.00		1000 U	10.0 UPH
		B07T18						10.0 UPH
		B07T19	750		7.00		1000 U	20.0 PH
		B07T19						20.0 PH
	3/24/93	B08B76	671		6.80		1000 U	30.0 BPH
		B08B77	669		6.79		1000 U	20.0 BPH
		B08B78	670		6.79		1000 U	20.0 PH
		B08B79	671		6.78		1000 U	10.0 PH
	7/07/93	B08P90	793	680	7.04	6.90	300 L	8.0 UP
		B08P91	790		7.05		400 L	8.0 UP
		B08P92	790		7.05		300 L	20.0 P
		B08P93	789		7.05		300 L	20.0 P
	9/20/93	B09741	700	680	7.16	7.20	300 L	8.0 UP
		B09742	703	700	7.15	7.20	300 L	8.0 UP
		B09743	702	690	7.14	7.40	400 L	20.0 P
		B09744	703	710	7.15	7.40	300 L	10.0 P
699-24-35	12/18/92	B07T21	517		7.19		1000 U	10.0 UPH
		B07T21						10.0 UPH
		B07T22	520		7.16		1000 U	10.0 UPH
		B07T22						10.0 UPH
		B07T23	523		7.16		1000 U	10.0 UPH
		B07T23						10.0 UPH
		B07T24	522		7.16		1000 U	10.0 UPH
		B07T24						10.0 UPH

Contamination Indicator Parameters for the Solid Waste Landfill Data for Reporting Period October 1, 1992 through September 30, 1993. (sheet 3 of 3)

Well Name	Collection Date	Sample Number	COND FIELD µmho /700w	COND LAB µmho /700w	pH FIELD .01/6.5-8.5s	pH LAB .01/6.5-8.5s	TOC ppb 1000/.	TOX ppb 10/.
699-24-35	3/24/93	B08B81	520		6.88		1000 U	10.0 UPH
		B08B82	511		6.95		1000 U	10.0 PH
		B08B83	502		7.01		1000 U	10.0 UPH
		B08B84	501		7.04		1000 U	10.0 PH
		B08B85					1000 U	20.0 PH
		B08B86					1000 U	10.0 UPH
		B08B87					1000 U	10.0 UPH
		B08B88					1000 U	10.0 UPH
	7/07/93	B08P95	569	500	7.42	7.20	400 L	10.0 P
		B08P96	568		7.41		300 L	8.0 UP
		B08P97	570		7.41		200 U	8.0 UP
		B08P98	569		7.39		400 L	8.0 UP
	9/20/93	B09746	487	490	7.33	7.70	300 L	8.0 UP
		B09747	487	490	7.32	7.70	300 L	8.0 UP
		B09748	487	500	7.32	7.60	300 L	8.0 UP
		B09749	486	500	7.31	7.70	300 L	8.0 UP
699-25-34C	12/17/92	B07T26	511		7.28		1000 U	
		B07T27	515		7.28		1000 U	10.0 UP
		B07T27						10.0 UP
		B07T28	516		7.27		1000 U	10.0 UP
		B07T28						10.0 UP
		B07T29	517		7.26		1000 U	10.0 P
		B07T29						10.0 UP
	3/24/93	B08B91	508		7.27		1000 U	10.0 UPH
		B08B92	508		7.25		1000 U	10.0 UPH
		B08B93	508		7.26		1000 U	10.0 UPH
		B08B94	509		7.25		1000 U	10.0 UPH
	7/01/93	B08PB0	524	530	7.14	7.50	200 U	8.0 UP
		B08PB1	523		7.13		200 U	8.0 UP
		B08PB2	524		7.13		200 U	8.0 UP
		B08PB3	523		7.14		200 U	8.0 UP
	9/16/93	B09751	542	550	7.26	8.00	200 U	8.0 UP
		B09752	542	530	7.25	8.10	300 L	8.0 UP
		B09753	541	550	7.25	8.20	300 L	8.0 UP
		B09754	543	550	7.24	8.00	300 L	8.0 UP
699-26-35A	12/17/92	B07T31	422		7.56		1000 U	10.0 UP
		B07T31						10.0 UP
		B07T32	423		7.58		1000 U	10.0 UP
		B07T32						10.0 UP
		B07T33	422		7.58		1000 U	10.0 UP
		B07T33						10.0 UP
		B07T34	420		7.57		1000 U	10.0 UP
		B07T34						10.0 UP
	7/01/93	B08PB5	432	420	7.49	7.60	200 U	8.0 UP
		B08PB6	429		7.57		200 U	8.0 UP
		B08PB7	430		7.52		200 U	8.0 UP
		B08PB8	430		7.46		200 U	8.0 UP

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APPENDIX 5.3B

WATER LEVEL MEASUREMENTS

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RCRA Water Level Measurement Report, SWL. (sheet 1 of 4)

Well	Date	Depth to water (ft)	Water level elevation above msl (ft)
Solid Waste Landfill Monitoring Wells			
699-23-34	10/23/92	131.04	401.82
	11/24/92	131.06	401.80
	12/17/92	131.06	401.80*
	12/30/92	131.14	401.72
	1/28/93	131.14	401.72
	2/23/93	131.19	401.67
	3/23/93	131.25	401.61*
	3/29/93	131.20	401.66
	4/27/93	131.27	401.59
	5/21/93	131.32	401.54
	6/28/93	131.34	401.52
	7/02/93	131.39	401.47*
	7/19/93	131.41	401.45
	8/16/93	131.50	401.36
	9/20/93	131.47	401.39
699-24-33	10/23/92	122.47	401.74
	11/17/92	122.80	401.41*
	11/24/92	122.50	401.71
	12/17/92	122.56	401.65*
	12/30/92	122.61	401.60
	1/28/93	122.58	401.63
	2/23/93	122.62	401.59
	3/23/93	122.66	401.55*
	3/29/93	122.64	401.57
	4/27/93	122.71	401.50
	5/21/93	122.79	401.42
	6/28/93	122.78	401.43
	7/02/93	122.77	401.44*
	7/19/93	122.85	401.36
	8/16/93	122.88	401.33
	9/20/93	122.91	401.30
	9/29/93	122.91	401.30*
699-24-34A	10/23/92	132.08	401.81
	11/24/92	132.10	401.79
	12/18/92	132.11	401.78*
	12/30/92	132.17	401.72
	1/28/93	132.15	401.74
	2/23/93	132.21	401.68

RCRA Water Level Measurement Report, SWL. (sheet 2 of 4)

Well	Date	Depth to water (ft)	Water level elevation above msl (ft)
Solid Waste Landfill Monitoring Wells			
699-24-34A	3/23/93	132.90	400.99*+
	3/29/93	132.23	401.66
	4/27/93	132.30	401.59
	5/21/93	132.35	401.54
	6/28/93	132.37	401.52
	7/02/93	133.05	400.84*+
	7/19/93	132.46	401.43
	8/16/93	132.52	401.37
	9/20/93	132.50	401.39
	9/30/93	132.64	401.25*
699-24-34B	10/23/92	131.68	401.82
	11/24/92	131.71	401.79
	12/18/92	131.78	401.72*
	12/30/92	131.77	401.73
	1/28/93	131.77	401.73
	2/23/93	131.81	401.69
	3/23/93	131.75	401.75*
	3/29/93	131.82	401.68
	4/27/93	131.89	401.61
	5/21/93	131.94	401.56
	6/28/93	131.97	401.53
	7/07/93	131.92	401.58*
	7/19/93	132.14	401.36
	8/16/93	132.09	401.41
	9/20/93	132.14	401.36*
	9/20/93	132.10	401.40
699-24-34C	10/23/92	130.78	401.80
	11/24/92	130.82	401.76
	12/18/92	130.81	401.77*
	12/30/92	130.87	401.71
	1/28/93	130.87	401.71
	2/23/93	130.84	401.74
	3/24/93	130.90	401.68*
	3/29/93	130.93	401.65
	4/27/93	131.01	401.57
	5/21/93	131.05	401.53
	6/28/93	131.07	401.51
	7/07/93	131.12	401.46*

RCRA Water Level Measurement Report, SWL. (sheet 3 of 4)

Well	Date	Depth to water (ft)	Water level elevation above msl (ft)
Solid Waste Landfill Monitoring Wells			
699-24-34C	7/19/93	131.15	401.43
	8/16/93	131.24	401.34
	9/20/93	131.25	401.33*
	9/20/93	131.20	401.38
699-24-35	10/23/92	136.99	401.82
	11/24/92	137.00	401.81
	12/18/92	137.02	401.79*
	12/30/92	137.07	401.74
	1/28/93	137.06	401.75
	2/23/93	137.11	401.70
	3/24/93	137.15	401.66*
	3/29/93	137.12	401.69
	4/27/93	137.20	401.61
	5/21/93	137.26	401.55
	6/28/93	137.27	401.54
	7/07/93	137.29	401.52*
	7/19/93	137.39	401.42
	8/16/93	137.42	401.39
	9/20/93	137.51	401.30
	9/20/93	137.46	401.35*
699-25-34C	10/23/92	133.66	401.80
	11/24/92	133.68	401.78
	12/17/92	133.77	401.69*
	12/30/92	133.75	401.71
	1/28/93	133.73	401.73
	2/23/93	133.78	401.68
	3/24/93	133.75	401.71*
	3/29/93	133.81	401.65
	4/27/93	133.87	401.59
	5/21/93	133.92	401.54
	6/28/93	133.94	401.52
	7/01/93	134.00	401.46*
	7/19/93	134.04	401.42
	8/16/93	134.51	400.95+
	9/16/93	134.15	401.31*
	9/20/93	134.18	401.28

RCRA Water Level Measurement Report, SWL. (sheet 4 of 4)

Well	Date	Depth to water (ft)	Water level elevation above msl (ft)
	Solid Waste Landfill Monitoring Wells		
699-26-35A	10/23/92	130.56	401.81
	11/24/92	130.54	401.83
	12/17/92	130.96	401.41*
	12/30/92	130.91	401.46
	1/28/93	131.16	401.21
	2/23/93	130.94	401.43
	3/24/93	130.76	401.61*
	3/29/93	130.96	401.41
	4/27/93	131.03	401.63
	5/21/93	131.08	401.58
	6/28/93	131.09	401.57
	7/01/93	131.41	401.25*
	7/19/93	130.97	401.69
	8/16/93	130.96	401.70
	9/20/93	131.89	400.77+
	9/20/93	131.22	401.44*

NOTES:
1. Water level elevations are calculated by subtracting the measured depth-to-water from the surveyed elevation for the well.
2. Depth-to-water values are transcribed from field records.
3. Elevations marked with an '*' were measured at the time of sampling.
4. Elevations marked with a '+' are outside of the expected range, and are suspected of error.
5. To convert feet to meters multiply by 0.3048.

CONTENTS

LIST OF FIGURES

6.0 300 AREA

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6.1 HYDROLOGIC SETTING OF THE 300 AREA

The following is a general discussion of the geology and hydrology within the 300 Area. More detailed information can be found in Swanson et al. (1992) and Schalla (1988).

6.1.1 Geology of the 300 Area

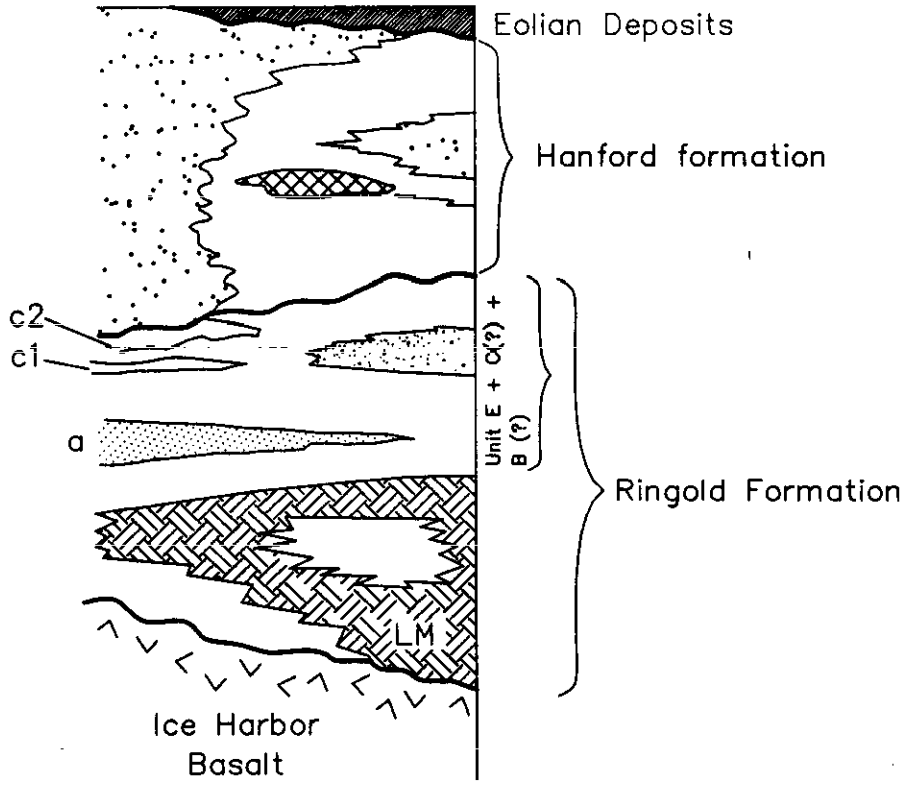
The 300 Area is structurally situated at the south end of the Cold Creek syncline. The general stratigraphy of the area can be divided into basalt units and suprabasalt sediments. Figure 6.1-1 shows the generalized stratigraphy of the 300 Area. The uppermost basalt is the Ice Harbor Member of the Saddle Mountains Basalt. The suprabasalt geologic unit found in the 300 Area are from oldest to youngest: (1) Ringold Formation, (2) Hanford formation, and (3) Holocene surficial deposits.

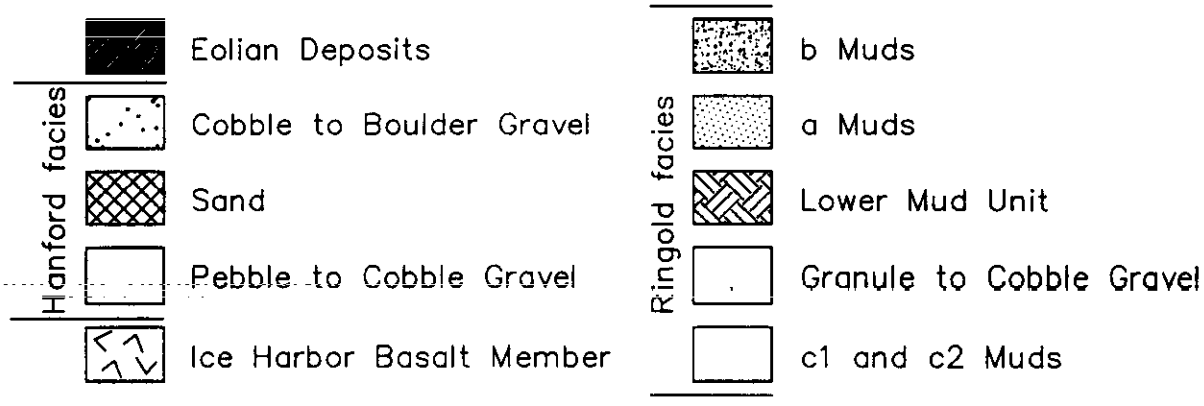
The Ringold Formation, about 46 m (150 ft) thick in the 300 Area, is generally divided into a lower, mud-dominated sequence and an upper, gravelly sequence. The lower mud unit, also known as the M-3 layer (DOE-RL 1990), is correlated to the lower mud unit that is found throughout the Pasco Basin near the bottom of the Ringold Formation (Delaney et al. 1991; Lindsey 1991; see Chapter 2.0). Every well in the 300 Area drilled to the depth of the lower mud unit has encountered it. Therefore, erosional windows through the lower mud unit do not appear to be present in the vicinity of the 300 Area. However the rapid thinning of the unit observed to the north and west of the 300 Area suggests that the unit may be absent adjacent to the 300 Area. The gravelly sequences overlying the lower mud unit are roughly correlative to the Ringold gravel units B, C, and E (Delaney et al. 1991; Lindsey 1991; see Chapter 2.0). The gravelly sequence is clast-supported granule-to-cobble gravel with a sandy matrix. Intercalated lenses of sand and mud also are found. Two mud-dominated intervals are found in the upper gravel sequence in the 300 Area.

The Hanford formation in the 300 Area consists of two of the three main facies discussed in Delaney et al. (1991). The thickness range of the Hanford formation is approximately 8 to 23 m (25 to 75 ft). It is dominated by pebble-to-boulder gravels typical of the gravel-dominated facies. Sandy horizons typical of the sand-dominated facies are present locally.

There is evidence of erosion and channelization of the top of the Ringold Formation throughout the 300 Area. This erosion has produced several lows in the top of the Ringold Formation that generally extend from west to east across the area.

Figure 6.1-1. General Stratigraphy in the 300 Area.





a, b, c1 and c2 muds, terminology taken from Swanson et al. 1992

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6.1.2 Hydrogeologic Units in the 300 Area

The suprabasalt aquifer system within the 300 Area is contained within the gravel and sands of the Hanford formation and the Ringold Formation. The geologic and hydrologic characteristics of these deposits are described in more detail in Swanson et al. (1992) and Schalla et al. (1988).

Unconfined and confined hydraulic conditions are present within the suprabasalt aquifer system in the 300 Area. The water table may either be within the Hanford formation or the Ringold Formation at a depth of 11 to 15 m (35 to 50 ft). The Ringold lower mud unit, approximately 9 m (30 ft) thick, acts as a confining layer. The hydraulic head of the confined aquifer beneath the lower mud unit is higher than that of the unconfined aquifer.

Transmissivity of the unconfined aquifer within the 300 Area was determined by aquifer tests and are reported in Swanson et al. (1992) and Schalla et al. (1988). Transmissivity ranges between 370 and 9,300 m^2/day (4,000 and 100,000 ft^2/day). The large range in transmissivity may be due to the wide range in sediment textures found within the 300 Area. Flow velocity estimated from sampling the perchloroethylene spill was about 11 m/day (35 ft/day) (Schalla et al. 1988).

6.1.3 Groundwater Flow in the 300 Area

The water level and flow direction in the unconfined aquifer near the Columbia River are related to fluctuations in river stage. The water level in wells monitoring the top of the unconfined aquifer fluctuates as much as 1.2 m (4 ft) over the year. High river stage occurs in late spring (May-June) and low stage in early fall (September-October) (see Figure 2-3). The groundwater flow direction of the unconfined aquifer is predominantly to the east within the 300 Area and in the surrounding area (Figure 6.1-2). East of the 1100 Area and south of the 300 Area there is a groundwater mound (see Figure 6.1-2). This mound locally distorts the general eastward flow direction. The mound is caused by the city of Richland's recharge basins. Flow reversal occurs when the river stage is higher than the water level in the unconfined aquifer. This reversal usually occurs in late spring and is a near river effect.

The confined aquifer is monitored at a few locations in and around the 300 Area. The direction of flow appears to be east-northeast based on regional data. The potentiometric level of the confined aquifer is above land surface in well 699-S22-E9C and 0.6 to 0.9 m (2 to 3 ft) below the land surface in well 399-1-17C. An upward gradient exists between the confined and unconfined aquifers. The head difference of about 11 m (35 ft) occurs near the 399-1-17 well cluster.

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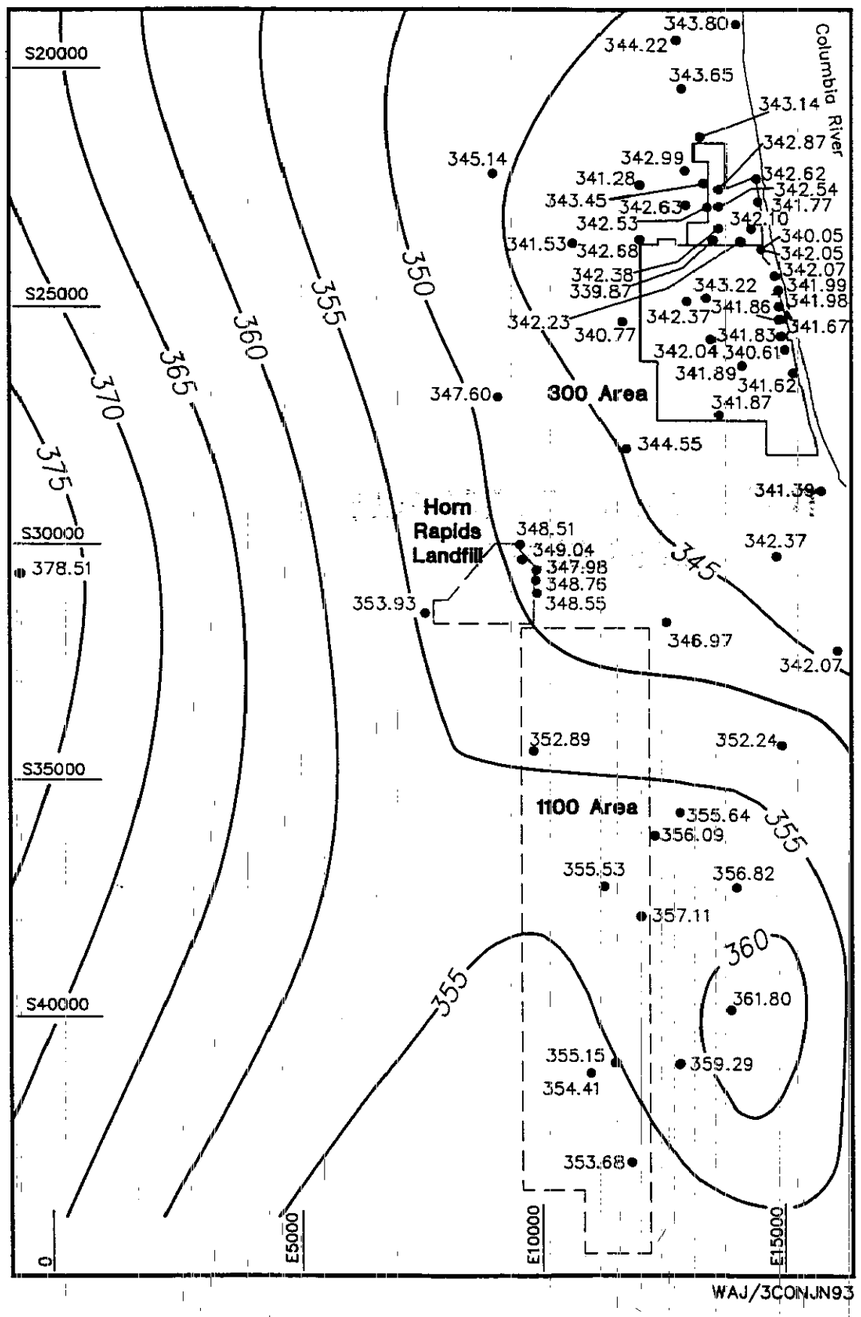
Figure 6.1-2. Water Table Elevation Map for the 300 and 1100 Areas.



300/1100 Area Water Table Map June 1993

354.19 ● Water table elevation (feet above mean sea level)

▲ Average river elevation—day of 300 Area water level measurement

350 Water table elevation Contour Interval = 5ft

The 300 Area water table map has been prepared by the Geohydrologic Engineering Function, Westinghouse Hanford Company.

Note: To convert to metric, multiply elevation (ft) by 0.3048 to obtain elevation (m).

0 1 Mile

0 1 Kilometer

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6.1.4 Groundwater Chemistry in the 300 Area

RCRA groundwater monitoring in the 300 Area was initiated in 1987 for the process trenches. At the beginning of RCRA monitoring a large number of 300 Area wells were sampled to determine the effects of the 316-5 Process Trenches apart from the other facilities in the 300 Area (i.e., North and South Process Ponds, and sanitary sewer system). DOE (1993) has identified contaminants of potential concern for the unconfined aquifer beneath the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) 300-FF-5 operable unit. These contaminants are: total coliform, chloroform, 1,2-dichloroethene, trichloroethene, ^{90}Sr, ^{99}Tc, tritium, total uranium, $^{234,235,238}U$, nitrate, nickel, and copper.

The contaminants of potential concern that can be associated with plumes within the 300 Area are ^{90}Sr and ^{99}Tc with the gross beta plume, tritium, and total uranium. The gross beta plume (Figure 6.1-3) centers around the northern part of the 300 Area. The tritium plume (Figure 6.1-4), which emanates from the 200 Areas, has reached the northern portion of the 300 Area at a level that is equal to the drinking water standard of 20,000 pCi/L. The uranium plume (Figure 6.1-5) has two centers, one in the northern portion of the 300 Area near the process trenches and the other located in the southeastern section of the 300 Area. The gross alpha plume (Figure 6.1-6) is of the same general shape as that of the uranium plume, because uranium is the primary alpha-emitter in the area.

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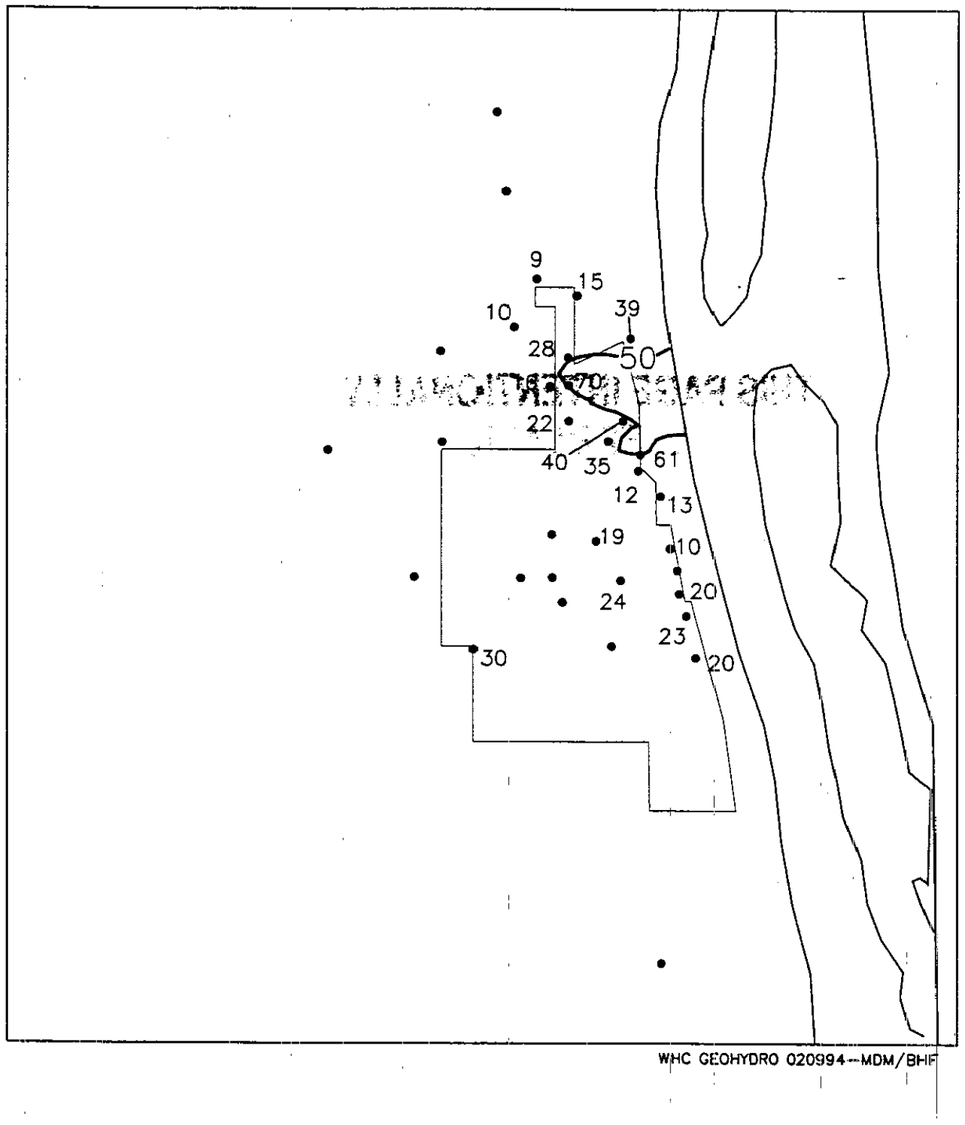
Figure 6.1-3. Gross Beta Distribution in Uppermost Aquifer, 300 Area.



300 Areas Gross Beta
Groundwater Plume Map

- Well Location
- 50 Concentration Isopleth pCi/L

This map was created from the average values for the period 1/1/91–10/1/93, with anomalous data points removed.

Detection Limit	.8 pCi/L
Drinking Water Standard	50 pCi/L
Maximum Concentration Limit	N/A
Washington Water Quality Standard	50 pCi/L
1/25 Derived Concentration Guide	N/A

0 200 400
METERS

0 600 1200
FEET

N

WHC GEOHYDRO 020994--MDM/BHF

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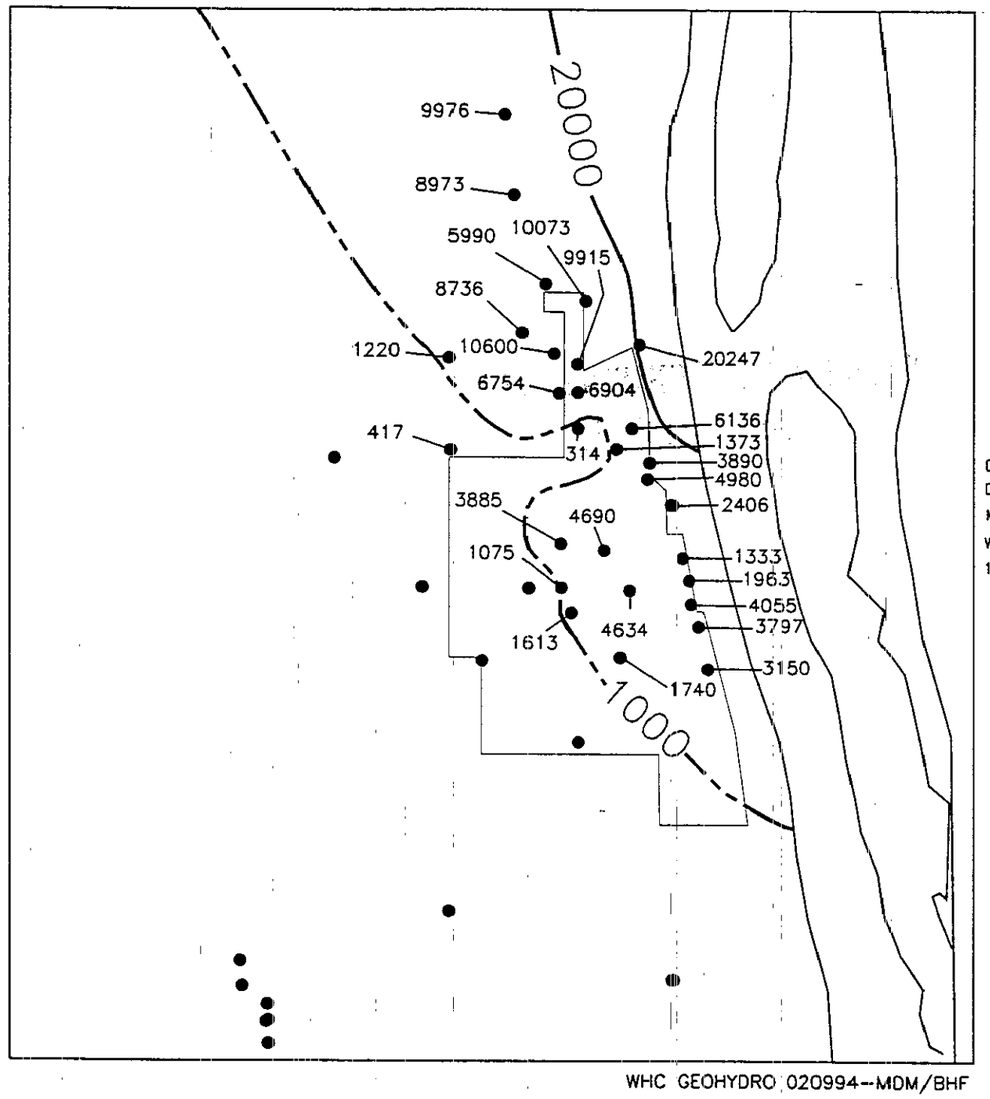
Figure 6.1-4. Tritium Distribution in Uppermost Aquifer, 300 Area.



WHC GEOHYDRO 020994--MDM/BHF

300 Areas Tritium Groundwater Plume Map

- Well Location
- 1000 Concentration Isopleth pCi/L

This map was created from the average values for the period 1/1/91–10/1/93, with anomalous data points removed.

Detection Limit	500 pCi/L
Drinking Water Standard	20000 pCi/L
Maximum Concentration Limit	20000 pCi/L
Washington Water Quality Standard	20000 pCi/L
1/25 Derived Concentration Guide	80000 pCi/L

0 200 400
METERS

0 600 1200
FEET

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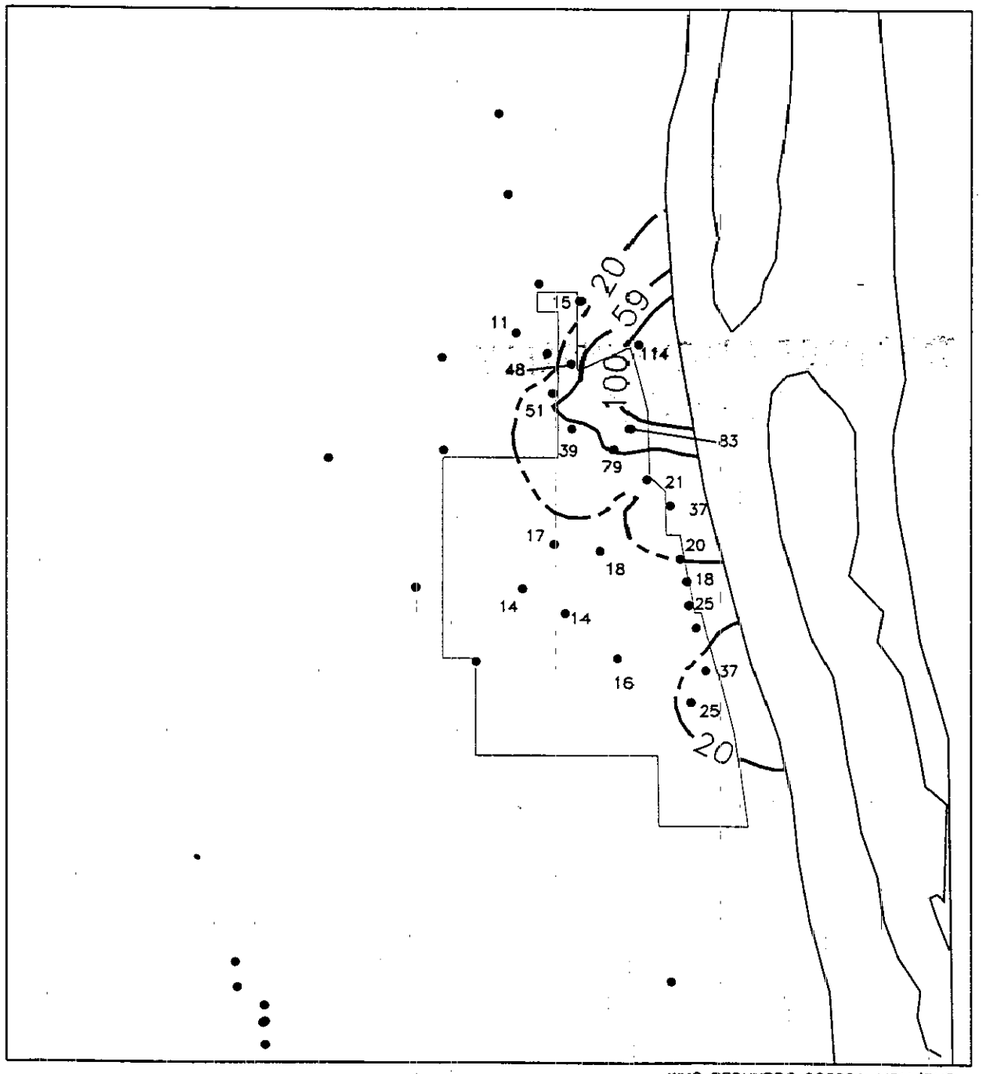
Figure 6.1-5. Uranium Distribution in Uppermost Aquifer, 300 Area.



300 Areas Uranium
Groundwater Plume Map

- Well Location
- 20 Concentration Isopleth pCi/L

This map was created from the average values for the period 1/1/91–10/1/93, with anomalous data points removed.

Detection Limit	0.1 pCi/L
Drinking Water Standard	40 pCi/L
Maximum Concentration Limit	40 pCi/L
Washington Water Quality Standard	N/A
1/25 Derived Concentration Guide	N/A

0 200 400
METERS

0 600 1200
FEET

N

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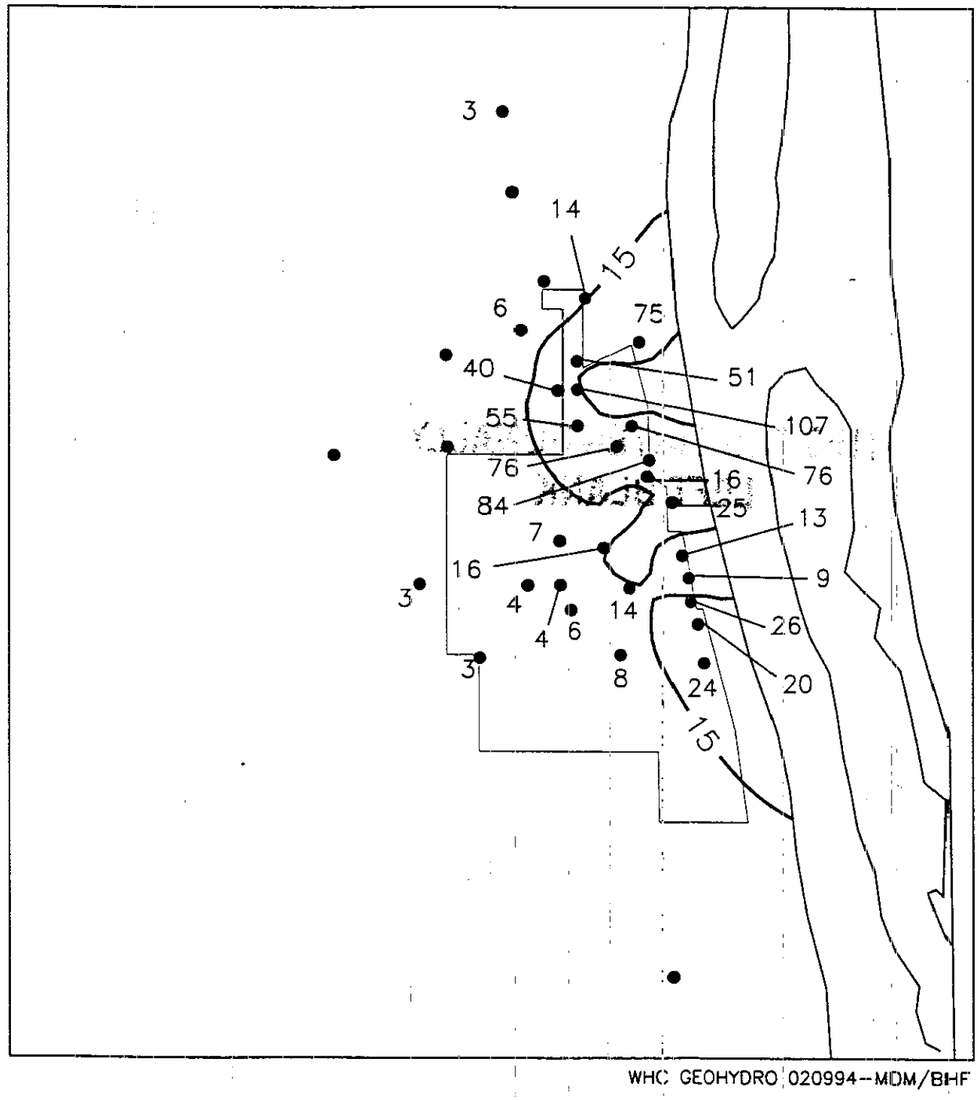
Figure 6.1-6. Gross-Alpha Distribution in Uppermost Aquifer, 300 Area.



300 Areas Gross Alpha Groundwater Plume Map

- Well Location
- 15 Concentration Isopleth pCi/L

This map was created from the average values for the period 1/1/91–10/1/93, with anomalous data points removed.

Detection Limit. 5pCi/L
Drinking Water Standard. . . . . 15 pCi/L
Maximum Concentration Limit . . . . . .N/A
Washington Water Quality Standard . . . 15 pCi/L
1/25 Derived Concentration Guide . . . . . .N/A

0 200 400
METERS

0 600 1200
FEET

N

WHC GEOHYDRO 020994--MDM/BHF

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6.2 300 AREA PROCESS TRENCH

J. V. Borghese
Pacific Northwest Laboratory

The groundwater near the 300 Area Process Trenches has been monitored by a *Resource Conservation and Recovery Act of 1976* (RCRA) interim-status groundwater quality assessment well network since June 1985. Monitoring wells were constructed in response to a *Consent Agreement and Compliance Order* issued jointly by Ecology and the EPA (Ecology and EPA 1986). The 300 Area Process Trenches are located within the *Comprehensive Environmental Response, Compensation and Liability Act of 1980* (CERCLA) operable units 300-FF-1 and 300-FF-5. Currently the 300 Area Process Trenches are in the groundwater quality assessment stage of monitoring as discussed in the groundwater monitoring compliance plan (Schalla 1988). A closure/post-closure plan has been written for the 300 Area Process Trenches and is described in DOE (1985).

6.2.1 Facility Overview

The 300 Area Process Trenches are located in the northern portion of the 300 Area (Figure 6.2-1). The two unlined trenches were constructed in 1975. The geology and hydrology of the 300 Area are discussed in Section 6.1.

From 1975 until the shutdown of fuel fabrication in 1987 and other 300 Area operations in 1988, the trenches were used for the disposal of most liquid wastes generated in the 300 Area. Waste constituents are described in Schalla et al. (1988). Discharge rate reached a maximum of about 7,600 L/min (2,000 gal/min). Since 1988, the wastewater has consisted of cooling water with small quantities of nonhazardous maintenance and process waste. In July 1991, the trenches were modified as part of an Expedited Response Action. The modifications of the trenches involved removing bottom sediment from the inflow end of the trench and placing it at the opposite end of the trench behind a berm. The trenches were used on an alternating, as-needed basis. The west trench was rendered inoperable on November 20, 1992. Since then, the east trench receives all discharge. Average discharge to the east trench is about 850 L/min (225 gal/min).

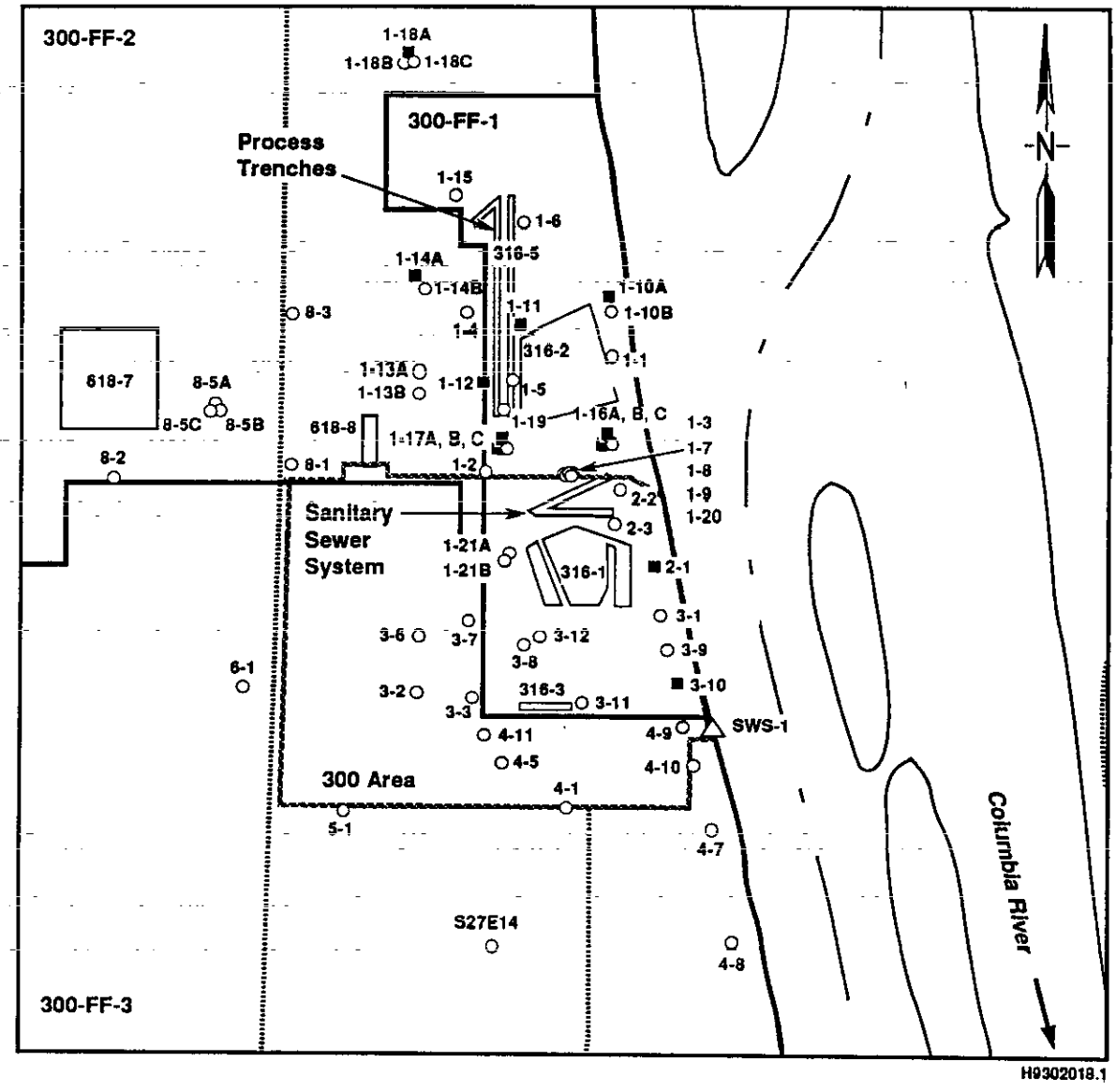
6.2.2 Summary of 1993 Activities

Two regular sampling events occurred in fiscal year 1993. Sampling of the monitoring wells occurred in February and September 1993. In addition to regular sampling events, one well is sampled quarterly for a limited list of analytes. Water level measurements are taken monthly, in addition to measurements made during sampling.

6.2.3 Other Activities in 1993

Other activities that occurred in 1993 were the remediation of well 399-1-16C by the CERCLA program, and special sampling in response to a release of ethylene glycol. Well 399-1-16C was remediated to solve the problem of hydraulic connection between the unconfined and the confined

Figure 6.2-1. Facility and Well Location Map.



○ 1-12 Well Location and Number (Wells Prefixed by 399-, Except Those Beginning with S are Prefixed with 699-)

■ 4-7 Monitoring Network Well

△ SWS-1 Surface-Water Monitoring Station

Roads

aquifer. The well was drilled and completed in 1987 in the confined aquifer. Within 6 months after completion the water level in the well was about 9 m (30 ft) lower than then the initial head measured in this well. The water level in the well equilibrated to that of the unconfined aquifer, which is about 9 m (30 ft) lower than that in the confined aquifer. The hydraulic connection may have been caused by inadequate seal in the annular space, casing joint leaks, and/or damage to casing. Since the completion of remediation the water level in the well is that of the confined aquifer.

On April 30, 1993, a spill of ethylene glycol occurred in the 309 Building and was subsequently released to the process sewer line. Samples of process water and groundwater have been collected to evaluate the impact of the ethylene glycol release. The sample from the weir box of the process trenches, approximately 5 hours after the discharge, contained an ethylene glycol concentration of 3,000 ppm. Analytical results of wells sampled on May 8, 14, and 20, 1993, indicate levels of ethylene glycol in groundwater are not significant (<5 ppm detection limit).

6.2.4 Sampling and Analysis Program

The general groundwater monitoring program is described in the groundwater monitoring compliance plan (Schalla 1988). Sampling of 300 Area wells is coordinated with the 300-FF-5 CERCLA program so that well trips can be reduced and data are shared.

There are currently 11 wells in the monitoring network for the process trenches. The locations of these wells are shown in Figure 6.1-1. A list of these 11 wells, other wells, and their uses are presented in Table 6.2-1.

Groundwater samples are collected semiannually at all wells in the network except well 399-1-17A, which is scheduled for quarterly sample collection. Well 399-1-17A is on a quarterly schedule to access changes in groundwater quality near the process trench.

Available analytical results have been reported in the quarterly reports (DOE-RL 1993a, 1993b, 1993c, 1994). A summary of analytical constituents is presented in Table 6.2-2.

6.2.5 Groundwater Chemistry

The process trenches are located near other liquid disposal facilities in the 300 Area. Because of the proximity to the North Process Ponds (no longer in service) and sanitary sewer lines, as well as other facilities downgradient from the process trenches, it is difficult to determine constituents in the groundwater that can be directly attributed to the process trenches.

6.2.5.1 Concentration Histories of Waste Indicators. A brief discussion of constituents of interest for the reporting period is provided in the following text. A list of the available analytical data for the reporting period is available in DOE-RL (1993a, 1993b, 1993c, 1994).

Table 6.2-1. Monitoring Wells Used for the 300 Area Process Trenches.

Well	Aquifer	Sampling frequency	Water levels	Well standards
399-1-10A[86]	Top of unconfined	SA	M	RCRA
399-1-11[86]	Top of unconfined	SA	M	RCRA
399-1-12[86]	Top of unconfined	SA	M	RCRA
399-1-14A[86]	Top of unconfined	SA	M	RCRA
399-1-16A[86]	Top of unconfined	SA	M	RCRA
399-1-16B[87]	Bottom unconfined	SA	M	RCRA
399-1-17A[86]	Top of unconfined	Q	M	RCRA
399-1-17B[86]	Bottom unconfined	SA	M	RCRA
399-1-18A[86]	Top of unconfined	SA	M	RCRA
399-2-1[48]	Top of unconfined	SA[a]	M	PRE
399-3-10[76]	Top of unconfined	SA[a]	M	PRE

Notes: Shading denotes upgradient wells. Superscript following well number denotes the year of installation.
[a]Well is sampled for supporting data.
M = frequency on a monthly basis.
PRE = well was constructed before RCRA-specified standards.
Q = frequency on a quarterly basis.
RCRA = well is in compliance with RCRA standards.
SA = frequency on a semiannual basis.

6.2.5.1.1 Uranium. Concentrations of uranium at well 399-1-17A are shown in Figure 6.2-2. Groundwater from well 399-1-17A has been analyzed for uranium since 1987. Before the Expedited Response Action in July 1991, uranium concentrations were greater than 100 ppb and showed cyclic variations. The cyclic variations were related to river stage fluctuations. However after the Expedited Response Action, uranium concentrations dropped to much lower values and stayed at the low values through the monitored period. Concentration of uranium at other sampled wells have remained consistent during the past year.

6.2.5.1.2 Gross Alpha. Concentrations of gross alpha activity above the drinking water standard (DWS) (15 pCi/L) were observed in wells 399-1-10, 399-1-11, 399-1-12, 399-1-16A, 399-1-7, and 399-2-1. All of these wells except 399-1-16A and 399-2-1 historically have had gross alpha values above the DWS.

6.2.5.1.3 Trichloroethylene/1,2-Dichloroethene. Groundwater collected from well 399-1-16B, which monitors the bottom of the unconfined aquifer, historically has had values of trichloroethylene and 1,2-dichloroethene above the DWSs of 5 and 70 ppb, respectively. 1,2-dichloroethene was also detected in well 399-1-16A.

Table 6.2-2. Constituents Analyzed in the 300 Area Process Trenches.

Contamination indicator parameters		
pH	Total organic carbon	
Specific conductance	Total organic halogen	
Groundwater quality parameters		
Chloride	Manganese	Sodium
Iron	Phenols	Sulfate
Drinking water parameters		
2,4-D	Chromium	Lead
2,4,5-TP Silvex	Coliform bacteria	Mercury
Alpha-BHC	Delta-BHC	Methoxychlor
Arsenic	Endrin	Nitrate
Barium	Fluoride	Radium
Beta-BHC	Gross alpha	Selenium
Cadmium	Gross beta	Silver
Site-specific and other parameters		
4,4-DDE	Cobalt	Phosphate
4,4-DDT	Copper	Potassium
Aldrin	Dieldrin	Tin
Alkalinity	Endosulfan	Toxaphene
Antimony	Endrin aldehyde	Tritium
Arochlor 10, 12	Heptachlor	Uranium
Beryllium	Magnesium	Vanadium
Bromide	Nickel	Volatile organics
Chlordane	Nitrate	Zinc

BHC = benzone hexachloride.

6.2.5.1.4 Tritium. Although tritium is not indicative of a contaminant from the process trenches, the plume emanating from the 200 Areas (see Figure 2-5) is influencing groundwater in the 300 Area. Figure 6.2-3 shows the change in concentration over time for selected wells in the 300 Area. Well 399-1-18A, the northernmost well in the network, has the highest concentration of tritium. Wells further south detect less tritium.

6.2.5.2 Distribution of Waste Constituents. The distribution of uranium in the groundwater beneath the 300 Area has changed since July 1991. Data before July 1991 showed an uranium plume with the high (120 pCi/L) centered around well 399-1-17A located at the inflow end of the process trenches (Evans et al. 1992). The 1992 and 1993 data show that the marked decrease in uranium at well 399-1-17A that occurred post-Expedited Response Action has been sustained. Figure 6.1-5 shows the uranium plume in the 300 Area.

Figure 6.2-2. Uranium Concentrations at Well 399-1-17A.

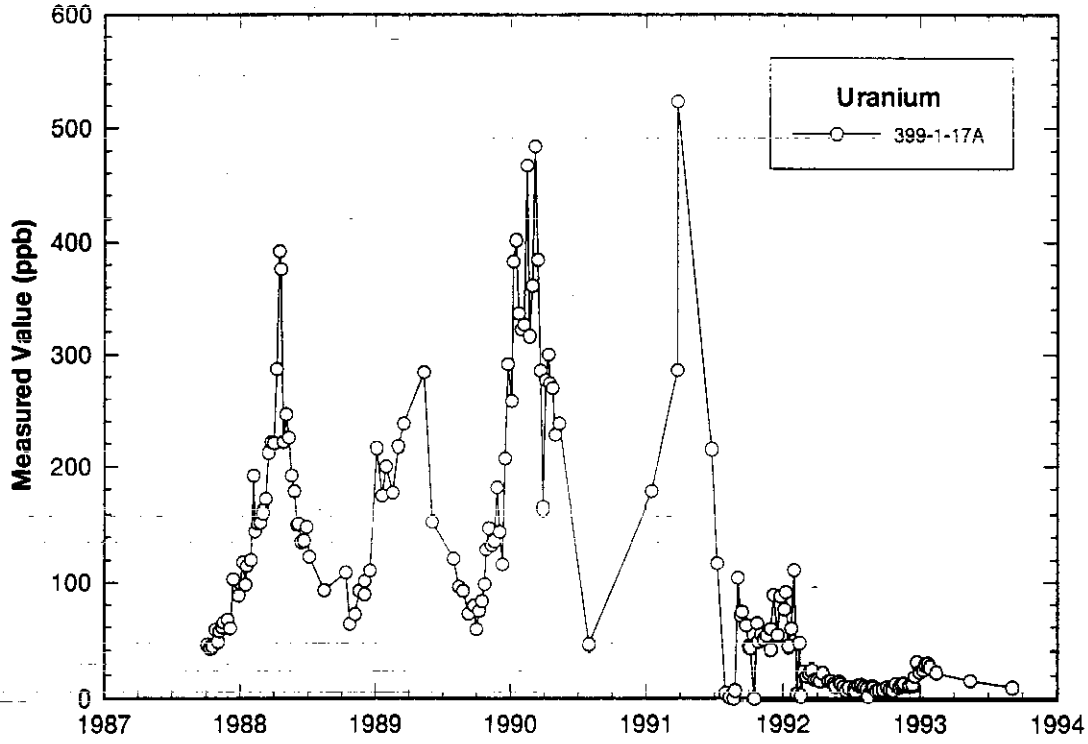
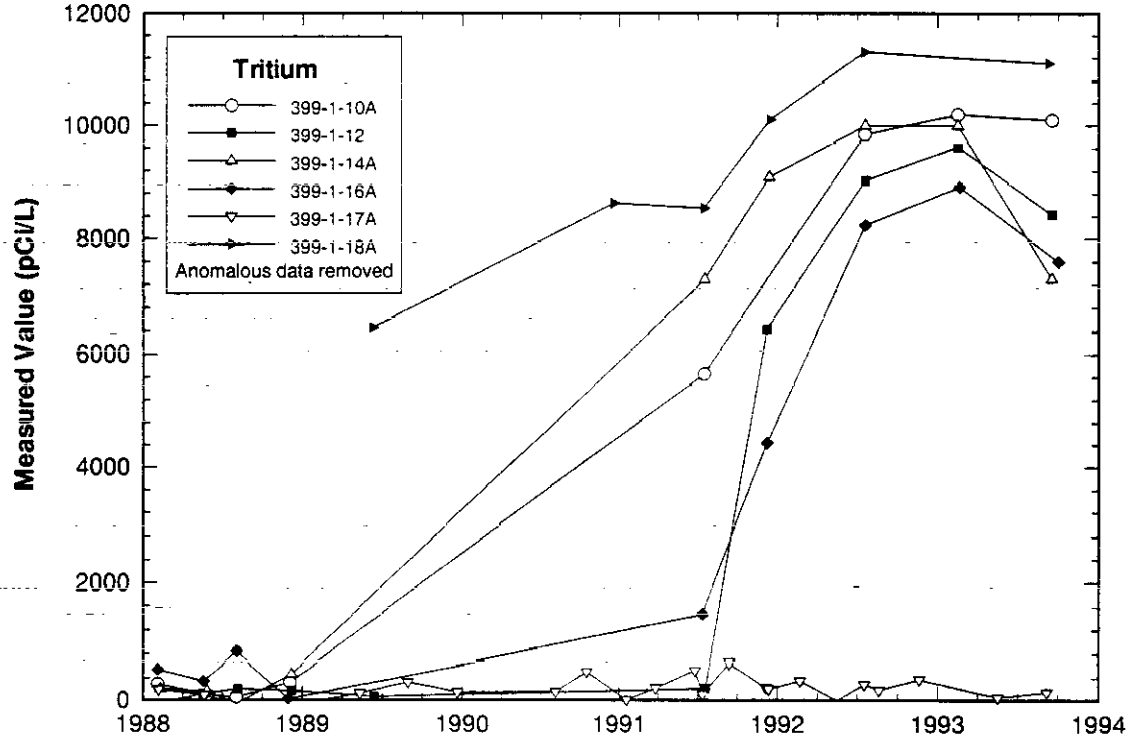


Figure 6.2-3. Tritium Activity in Selected 300 Area Wells.



6.2.6 Groundwater Flow

6.2.6.1 Groundwater Flow Direction. The groundwater flow direction in the unconfined aquifer near the 300 Area Process Trenches is predominantly to the southeast with slight changes due to fluctuations in Columbia River stage. Figure 6.2-4 shows the elevation of the water table on May 26, 1993, when the river stage was very near the high for the year. There is a localized flow reversal when the river stage is higher than the water level in the unconfined aquifer. Figure 6.2-5 shows the elevation of the water table on September 27, 1993, during the low stage period for the Columbia River. Water level data are collected monthly and reported in quarterly reports (DOE-RL 1993a, 1993b, 1993c, 1994).

There is a vertical head difference, with the gradient in an upward direction, between the unconfined aquifer above the Ringold lower mud unit and the gravels beneath the mud. At well 399-1-17A the head difference is about 11 m (35 ft). There is a slight downward gradient within the unconfined aquifer. The head difference within the unconfined aquifer is observed in the 399-1-17 and 399-1-16 well cluster.

6.2.6.2 Rate of Flow. The flow rate in the top of the unconfined aquifer has previously been reported as about 10.6 m/d (35 ft/d) near the process trenches (Schalla et al. 1988) based on a perchloroethylene spill data. The rate of flow can also be estimated roughly by using the Darcy equation.

$$v = \frac{Ki}{n} \qquad (1)$$

where:

v = Average linear groundwater velocity
K = Hydraulic conductivity
i = Hydraulic gradient
n = Effective porosity.

Schalla et al. (1988) reported values of hydraulic conductivity determined from pumping tests for the unconfined aquifer ranging from 150 to 15,240 m/d (500 to 50,000 ft/d). The hydraulic gradient near the process trenches, estimated from the September 1993 water table maps, averages to 0.0007. This gradient is about average for the year. Estimates of effective porosity for the unconfined aquifer range from 0.10 to 0.30. Using the above-stated values for input parameters to the Darcy equation, the range of groundwater flow velocity is approximately 0.11 to 32 m/d (0.35 to 105 ft/d). The large range in flow velocity values is a result of the large range in values of hydraulic conductivity reported for the aquifer. The range in hydraulic conductivity may be attributed to the difference in geologic deposits.

6.2.6.3 Evaluation of Monitoring Network. Groundwater flow has not changed significantly since the 300 Area Process Trenches monitoring network was designed. The network is still adequate to detect contamination from the trenches.

Figure 6.2-4. Water Table Elevation Map, May 26, 1993.

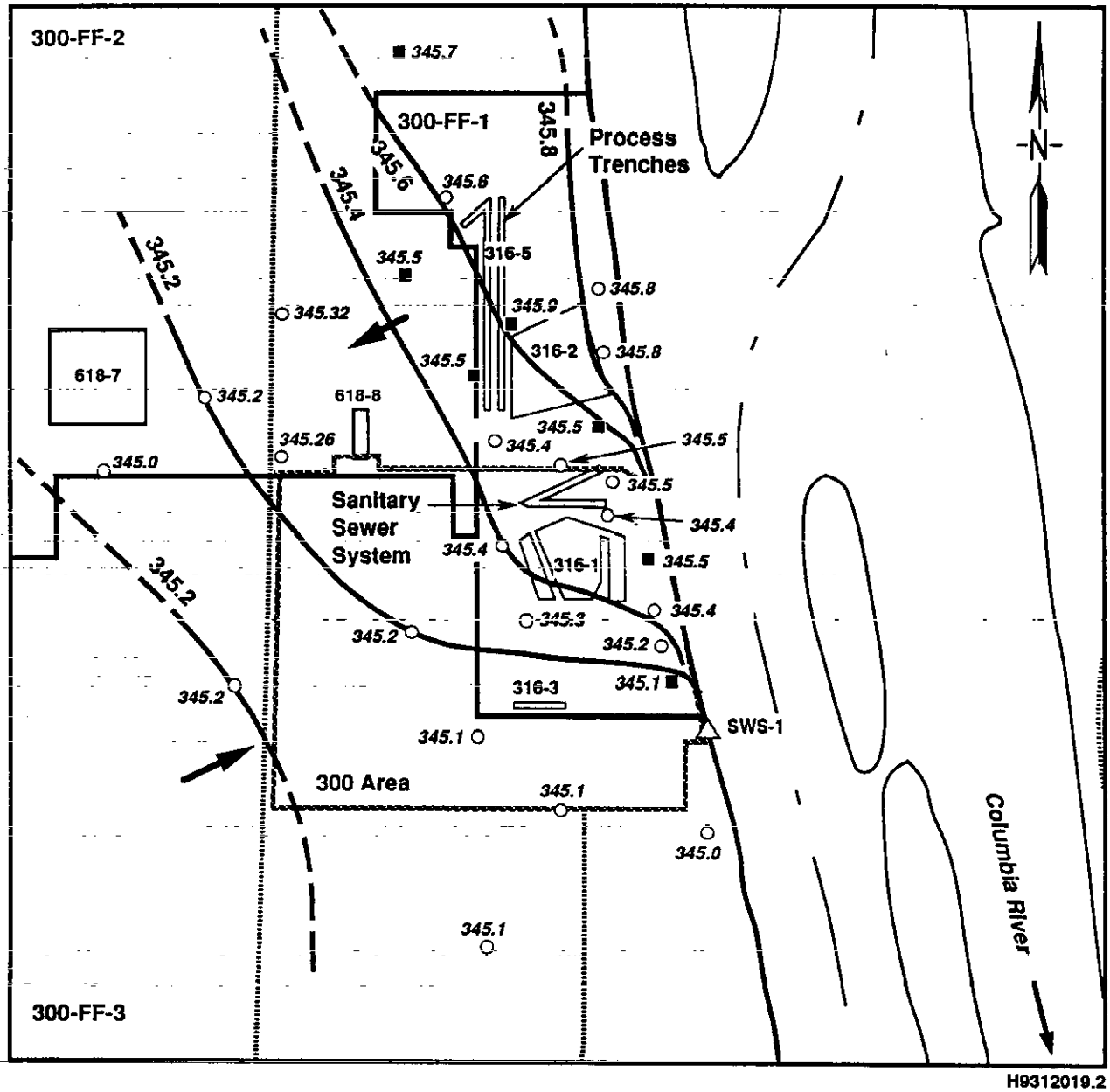
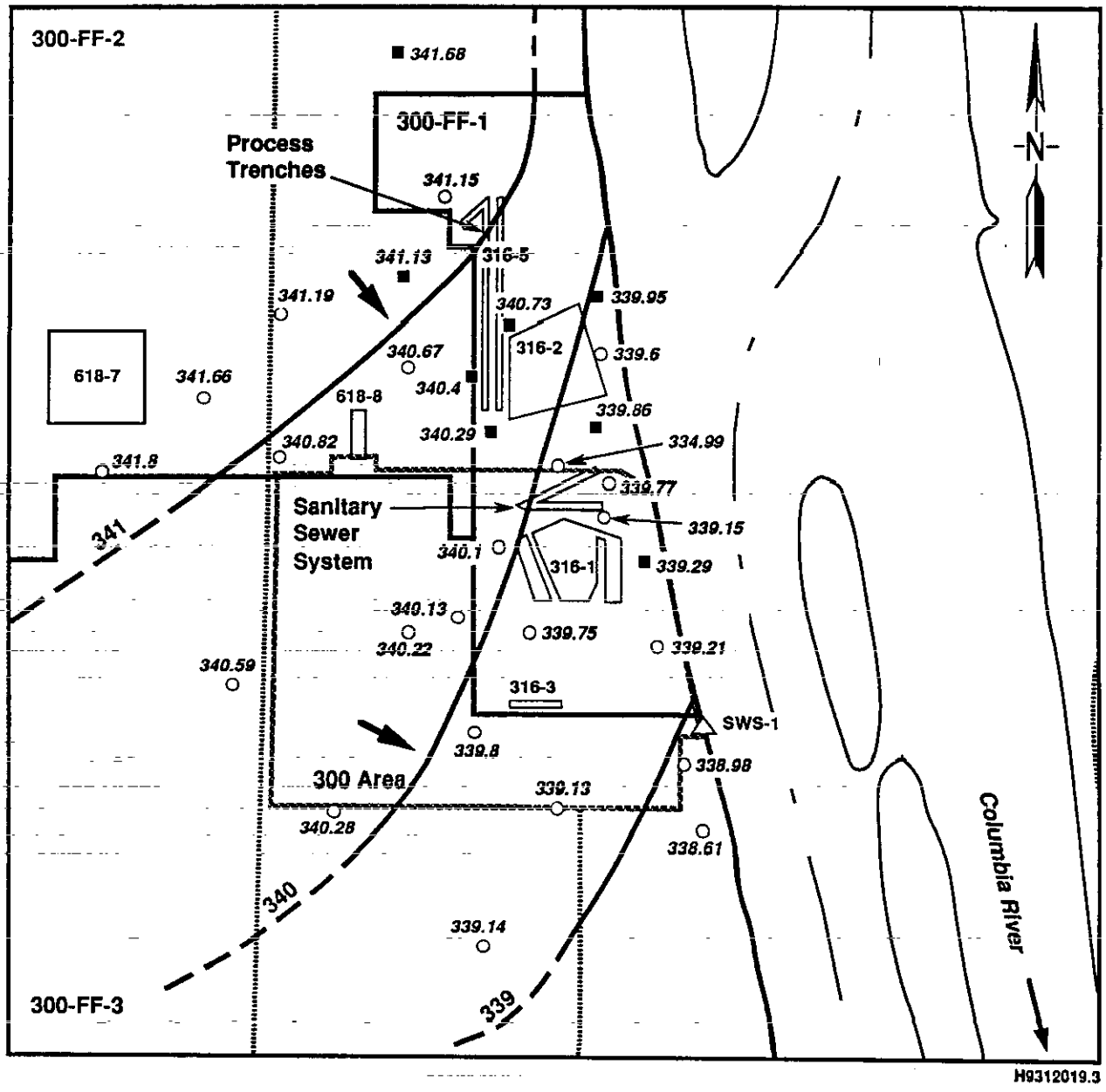


Figure 6.2-5. Water Table Elevation Map, September 27, 1993.



○ 1-12 Well Location and Number

■ 4-7 Monitoring Network Well

△ SWS-1 Surface-Water Monitoring Station

Roads

Generalized Flow Direction

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APPENDIX A

QUALITY CONTROL

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APPENDIX A

QUALITY CONTROL

A.0 QUALITY CONTROL PROGRAM

J. C. Johnston/S. M. Kitchka/A. W. Stites/T. X. Washington
Westinghouse Hanford Company

A.1 INTRODUCTION

The *Resource Conservation and Recovery Act of 1976* (RCRA) Quality Control (QC) program is based on guidance from the U.S. Environmental Protection Agency (EPA), the *Resource Conservation and Recovery Act (RCRA) Groundwater Monitoring Technical Enforcement Guidance Document* (EPA 1986a), and Chapter One, "Quality Control," from *Test Methods for Evaluating Solid Waste* (EPA 1986b).

A.1.1 Data Quality Objectives

The QC program uses the five data quality indicators precision, accuracy, representativeness, completeness, and comparability, along with applicable program-specific quality parameters to evaluate the quality of the data and the analytical laboratories analyzing the samples. Target values for precision and accuracy are specified in *Quality Assurance Project Plan for RCRA Groundwater Monitoring Activities* (WHC 1992b).

1. Precision is evaluated using data results from laboratory duplicates, matrix spike duplicates (see Section A.3), field duplicates, and blind samples (see Section A.2).

2. Accuracy is evaluated using data results from laboratory matrix spikes; laboratory control samples; EPA Water Pollution (WP), Water Supply (WS), and Interlaboratory Performance Evaluation Programs (see Section A.3); and by blind samples (see Section A.2).

3. Representativeness expresses the degree to which RCRA facility groundwater monitoring data represent the real composition of the groundwater in the aquifer. Goals for data representativeness for groundwater monitoring programs are addressed qualitatively by the specification of well construction, sampling locations, sampling intervals, and sampling and analyses techniques in the groundwater monitoring plan for each RCRA facility.

4. Completeness is defined as the percentage of measurements made that are judged to be valid measurements. Completeness is determined by the number of data unflagged during validation, divided by the total number of data validated, and multiplied by 100. The calculated percentages used in reporting completeness are conservative figures and are based on the data flags P, F, D, Q, and/or H.

5. Comparability is used to ensure that samples analyzed by different laboratories or by the same laboratory over different time periods are comparable. For 1993, only the primary hazardous chemistry and radiochemistry laboratories were requested to analyze samples and submit data. Samples were analyzed in accordance with *Test Methods for Evaluating Solid Waste* (EPA 1986b) and other applicable approved methods. Comparability of field measurements is determined by following approved sampling procedures that ensure consistency among sampling events.

A.2 EXTERNAL QUALITY CONTROL PROGRAM

The external QC program uses three kinds of QC samples to evaluate quality in the field and laboratory. These are field duplicates, field blanks, and blind samples.

The QC analytical results are judged to be acceptable if the following evaluation criteria are met.

- Field duplicates--Results of field duplicate pairs must have precision as measured by relative percent differences within ± 25%.

- Blanks--Four kinds of blanks are used to check for contamination resulting from field activities and/or bottle preparation. These are full trip blanks, daily trip blanks, field transfer blanks, and bottle blanks.

  Except for common laboratory contaminants, results above the limit of two times the method detection limit (MDL) are identified as suspected contamination. For common laboratory contaminants, such as acetone, methylene chloride, 2-butanone, toluene, and phthalate esters, sample results less than five times the MDL are qualified as nondetects.

- Blind samples--Results must fall within 2.0 standard deviations from the mean recovery of the known concentration of samples submitted to the laboratory.

Table A-1 provides a summary of the QC results available for 1993.

Results of the field blank and field duplicate analyses for 1993 are summarized in Tables A-2 and A-3. Tables A-2 and A-3 summarize the total number of field blanks and field duplicates outside of the QC limit per analyte for 1993. Analytes not listed in Tables A-2 or A-3 were 100% acceptable for field blanks or field duplicates.

A.3 INTERNAL QUALITY CONTROL PROGRAM

The internal QC program uses four types of QC data to establish and monitor performance in the laboratory. These data are laboratory blanks, matrix spikes, matrix duplicates, and EPA studies (WP and WS).

Table A-1. Summary of 1993 Quality Control Quarterly Reports.

Quarterly reports	Blinds (% acceptable)	Field duplicates (% acceptable)	Field blanks (% acceptable)
October-December 1992	None sent	97.4	98.3
January-March 1993	None sent	95.6	99.6
April-June 1993	None sent	95.9	96.9
July-September 1993	None sent	94.5	98.2

Every quarter each contracted laboratory supplies its own QC report, which includes data quality information on matrix spikes, matrix duplicates, and blanks in the form of precision and accuracy. The contracted laboratories also supply a report of their results for the EPA's WP, WS, and radiochemical intercomparison studies on a quarterly basis. The results of EPA studies independently verify the continuation of laboratory performance and are expressed as the percentage of EPA-accepted results. Each half-year the contracted laboratories also supply an MDL/minimum determined concentration (MDC) report. The MDLs and MDCs are required to be below the contractually required quantitation limit (CRQL). The CRQL is not associated with a quantitation limit as the name suggests. It is intended to be the lowest analyte concentration in a given matrix that a laboratory can be expected to detect consistently. The CRQL is agreed upon under the contractual statement of work. A laboratory nonconformance report (NCR) is issued when the MDL is greater than the CRQL. Westinghouse Hanford Company (WHC) reviews each of these reports and summarizes the results below in this section.

Precision and accuracy results from the primary contract laboratories, summarized in Table A-4, indicate the performance of all customers submitting water matrix samples. WHC samples represent only a part of the performance summary.

Radiochemistry precision and accuracy figures are gleaned from the radiochemistry laboratory's quarterly report, with percent acceptability calculated from duplicates and spikes, respectively. These results, along with radiochemistry blank data, are summarized in Table A-4.

During the quarter of October through December 1992, the internal QC section of the RCRA Groundwater Monitoring quarterly report (DOE-RL 1993b) reported results of a limited number of laboratory blanks, duplicates, and spikes from a variety of methods and analytes. The usefulness of this data was assessed, and the following quarter (January through March 1993), the present system of evaluating laboratory QC parameters was initiated. For the remainder of fiscal year (FY) 1993, internal (laboratory) QC for hazardous chemistry focused on specific areas of analysis that have been of concern in the past.

Table A-2. Field Blanks Exceeding Quality Control Limits.

Constituent name	Method	Total analyses	Blanks Out of QC limits	% Out of QC limits
1,1,1-Trichloroethane	SW-8240	650	3	0.5
Acetone	SW-8240	650	173	26.6
Aluminum	SW-6010	743	40	5.4
Ammonium ion	ASTM D-1426-C	92	44	47.8
Ammonium ion	ASTM D-1426-D	595	101	17.0
Antimony	SW-6010	1,812	19	1.0
Arsenic	SW-7060	1,547	67	4.3
Beryllium	SW-6010	1,812	59	3.3
Calcium	SW-6010	1,812	320	17.7
Carbon tetrachloride	SW-8240	650	18	2.8
Chloride	ASTM D-4327-88	959	7	0.7
Chromium	SW-6010	1,812	62	3.4
Copper	SW-6010	1,812	40	2.2
Endosulfan sulfate	SW-8080	656	19	2.9
Fluoride	ASTM D-4327-88	959	15	1.6
Gross beta	SW-9310 Beta	960	8	0.8
Iodine-129	ITAS I-129	137	1	0.7
Iron	SW-6010	1,812	83	4.6
Lead	SW-7421	1,531	67	4.4
Manganese	SW-6010	1,812	22	1.2
Methylene chloride	SW-8240	650	194	29.8
Nitrate	ASTM D-4327-88	959	29	3.0
Potassium	SW-6010	1,812	87	4.8
Sodium	SW-6010	1,812	398	22.0
Technetium-99	ITAS Tc-99	271	6	2.2
Tetrahydrofuran	SW-8240	650	3	0.5
Total carbon	ASTM D-2579-A	265	15	5.7
Total organic carbon	SW-9060	2,912	50	1.7
Total organic halogen	SW-9020	4,674	74	1.6
Tritium	ITAS H-3	851	12	1.4
Turbidity	Std Meth 214A	845	98	11.6
Zinc	SW-6010	1,812	131	7.2

Table A-3. Field Duplicates Exceeding Quality Control Limits.
(sheet 1 of 2)

Constituent name	Method	Total analyses	Duplicates Out of QC limits	% Out of QC limits
Acetone	SW-8240	650	3	0.5
Aluminum	SW-6010	743	6	0.8
Ammonium ion	ASTM D-1426-D	595	2	0.3
Antimony-125	ITAS δ Scan	312	10	3.2
Arsenic	SW-7060	1,547	6	0.4
Barium	SW-6010	1,812	4	0.2
Beryllium	SW-6010	1,812	4	0.2
Bromide	ASTM D-4327-88	959	2	0.2
Calcium	SW-6010	1,812	2	0.1
Carbon tetrachloride	SW-8240	650	2	2.4
Cesium-137	ITAS δ Scan	315	4	1.3
Chloroform	SW-8240	650	2	0.3
Chloroform	SW-8010/8020	85	2	2.4
Chromium	SW-6010	1,812	26	1.4
Cobalt	SW-6010	1,812	6	0.3
Cobalt-60	ITAS δ Scan	315	6	1.9
Copper	SW-6010	1,812	8	0.4
Cyanide		83	2	2.4
Delta-BHC	SW-8080	656	2	0.3
Di-n-butylphtahlate	SW-8270	93	2	2.2
Dieldrin	SW-8080	656	2	0.3
Fluoride	ASTM D-4327-88	959	10	1.0
Gross alpha	SW-9310 Alpha	941	18	1.9
Gross beta	SW-9310 Beta	960	14	1.5
Iron	SW-6010	1,812	44	2.4
Lead	SW-7421	1,531	32	2.1
Magnesium	SW-6010	1,812	2	0.1
Manganese	SW-6010	1,812	18	1.0
Methylene chloride	SW-8240	650	4	0.6

Table A-3. Field Duplicates Exceeding Quality Control Limits.
(sheet 2 of 2)

Constituent name	Method	Total analyses	Duplicates Out of QC limits	% Out of QC Limits
Nickel	SW-6010	1,812	28	1.5
Nitrate	ASTM D-4327-88	959	6	0.6
Nitrite	ASTM D-4327-88	959	2	0.2
Potassium	SW-6010	1,812	4	0.2
Radium	SW-9315 Radium	749	8	1.1
Ruthenium-106	ITAS δ Scan	315	4	1.3
Selenium	SW-7740	1,539	6	0.4
Silver	SW-6010	1,812	4	0.2
Sodium	SW-6010	1,812	4	0.2
Sulfide	SW-9030	176	2	1.1
Technetium-99	ITAS Tc-99	271	2	0.7
Toluene	SW-8240	650	2	0.3
Total organic carbon	SW-9060	2,912	16	0.5
Total organic halogen	SW-9020	4,674	18	0.4
Trichloroethene	SW-8240	650	4	0.6
Tritium	ITAS H-3	851	2	0.2
Turbidity	Std Meth 214A	845	12	1.4
Vanadium	SW-6010	1,812	10	0.6
Zinc	SW-6010	1,812	26	1.4

Table A-4. Summary of 1993 Quality Control Semiannual and Quarterly Reports (in percent acceptable).

1993 Quarterly reports	Precision* (% acceptable)	Accuracy* (% acceptable)	EPA water pollution (% acceptable)	EPA water supply (% acceptable)	Radiochemical interlab comparison (% acceptable)
Oct-Dec 1992	97.2	100	97.2%	Samples not sent this quarter	100% (11/92 - 02/93)
Jan-Mar 1993	95.6	98.2	Not reported by lab	Not reported by lab	Not received
Apr-Jun 1993	98.8	97.8	97.7%	Samples not sent this quarter	100% (03/93 - 05/93)
Jul-Sept 1993	97.8	97.7	Samples not sent this quarter	98.7%	100% (06/93 - 08/93)

*These figures represent radiochemistry data.

The following constituents were identified by the QC task team to have analysis results outside QC limits for at least 5% of the total analyses: acetone (26.6%), aluminum (5.4%), ammonium ion (47.8% and 17.0%), calcium (17.7%), methylene chloride (29.8%), sodium (22.0%), total carbon (5.7%), turbidity (11.6%), and zinc (7.2%). The QC task team has begun investigation with the sampling and laboratory contract administrator in an effort to locate the cause of contamination of the field blanks.

For the quarter of January through March 1993, 100% of the total organic halogen (TOX) data for matrix spike duplicates and matrix spikes were evaluated for precision and accuracy, respectively. The number of datapoints found to be outside QC limits was unacceptable, and, therefore, addressed at the August 4-6, 1993 audit of the hazardous chemistry laboratory.

The following quarter all evaluation of hazardous chemistry internal QC data focused on inductively coupled plasma (ICP) metals of particular concern. The metals chosen for evaluation were calcium, chromium, iron, nickel, sodium, and zinc. One hundred percent of the matrix duplicates and matrix spikes were evaluated for these constituents. Based on this evaluation and past data, an audit of the laboratory's ICP metals area of analysis was determined to be necessary. A summary of the audit findings is found in Section A.5, Quality Assurance Occurrences.

During third quarter of FY 1993, all evaluation of internal QC focused on total organic carbon (TOC) and total carbon because of concern for the quality of the analytical results. Because of this evaluation, the QC task team has determined that an audit of the hazardous chemistry laboratory is necessary.

A.4 NONCONFORMANCE/INCIDENT REPORTS

NCRs and incident reports are methods of documentation by which contract laboratories can inform laboratory contractors and their customers of any problems encountered with the analysis, data, and/or data deliverable. This method of documentation is intended to identify occurrences, deficiencies, or issues that may potentially have an adverse effect on the data integrity. These may include, but are not limited to the following:

- Lost sample
- Broken bottles
- Instrument malfunctions
- Calibration standards out of acceptable range
- Laboratory control standards out of acceptable range
- Matrix spike recovery out of acceptable range
- Blank contamination
- Procedural noncompliance
- Chain-of-custody discrepancies
- Shipping temperatures out of acceptable range
- Misreported data.

During the reporting year 141 NCR/incident reports were transmitted. The reports affect less than 5% of the results for the reporting year. There were 98 reports transmitted from the hazardous chemistry laboratory, and 43 reports transmitted from the radiochemistry laboratory. The reports have been instrumental in identifying potential issues for laboratory surveillances.

The following is a breakdown of the NCR/incident reports submitted during the reporting year by the hazardous chemistry laboratory: container received broken (33 reports); temperature out of compliance (17 reports); QC out of control limits (20 reports); incorrect sample preparation (9 reports); hold time missed (5 reports); and other miscellaneous occurrences (14 reports).

The following is a breakdown of the NCR/incident reports submitted during the reporting year by the radiochemistry laboratory: Re-reported data (19 reports); matrix effect problems (13 reports); lost in lab (7 reports); and other miscellaneous occurrences (4 reports).

A.5 QUALITY ASSURANCE OCCURRENCES

A surveillance of the gross alpha, beta, and gamma scan analyses was done in April 1993. Through the surveillance, it was discovered that there was a need for the laboratory to update several procedures and calibrate the alpha and beta gas proportional counters. An incident report was received during the inspection that confirmed a laboratory error in reporting a select batch of samples analyzed for total uranium. The error was a dilution factor not incorporated into the final data report. The surveillance also included a followup to the ^{40}K surveillance conducted during May 1992 (see Annual Report for RCRA Groundwater Monitoring Projects at Hanford Site Facilities for 1992, Chpt. 1.4.5, DOE-RL 1993a). The gamma scan software was found to still give false positives for the ^{40}K isotope. This does not affect the current contract because ^{40}K is no longer a reported analyte. However, if ^{40}K is requested in the future, the software must be corrected to ensure accurate determinations of this isotope.

During the first quarter of calendar year (CY) 1992, an occurrence of ^{40}K was found in field blank results. A surveillance of the gamma scan analysis for ^{40}K was done on the primary radiochemistry laboratory in May 1992. Through the surveillance, it was discovered that ^{40}K results in the field blanks were caused by naturally occurring ^{40}K in the background. The background peak value was not being subtracted in the analysis software, and registered as a false positive. The laboratory contractor presented this finding to the radiochemistry laboratory in a report in August 1992. The radiochemistry laboratory responded with corrective action in September 1992. The laboratory contractor accepted the corrective action of the radiochemistry laboratory during March 1993. The corrective action was to flag all of the affected ^{40}K data with the appropriate "XYZ" comment code for "estimated concentration-background included," and write a memo to file explaining the ^{40}K data were calculated without the appropriate background subtraction. This was implemented as of August 1993. This resolves the ^{40}K inspection.

An inspection of services of the hazardous chemistry laboratory was conducted August 4-6, 1993. The inspection was in response to increasing concern for the quality of ICP metals data and as a followup on the previous inspection of TOX. A summary of the inspection findings and observations is provided in the following paragraph.

The inspection team found evidence supporting eight findings and three observations, they are as follows:

Finding #1--Re-profiling of ICP instrumentation was found to have occurred without the required recalibration.

Finding #2--For TOX analyses, instances were found when the B column was greater than 10% of the total (of the A + B columns) without the required reanalysis being performed.

Finding #3--Documentation of training for the TOX analyst was such that it could not be determined that required training of the analyst to Rev. 1 of IW-BA-9020 was accomplished before the analysis of samples by the analyst.

Finding #4--Data were misreported for TOX analyses.

Finding #5--The February 1993 MDL study included misreported data.

Finding #6--ICP data generated since implementation of the February 1993 MDL study values have been misreported.

Finding #7--Noncompliances were found with the laboratory procedure governing nonconformance reporting.

Finding #8--It was found that Type II reagent water being used did not comply with the preparation requirements of ASTM procedure D1193-77 (1983).

Observation #1--Blank subtraction was not performed for TOX analyses as per IW-BA-9020, Rev. 1.

Observation #2--The laboratory procedure was not being followed for glassware cleaning.

Observation #3--Calibration standards associated with the ICP analyses were being used past the expiration dates.

The above findings and observations were forwarded to the hazardous laboratory and require a written response to addressing each issue.

A.6 LIMIT OF DETECTION, LIMIT OF QUANTIFICATION, AND METHOD DETECTION LIMIT

The concentration at which an analyte can be detected depends on the variability of the blank response. For purpose of this discussion, the 'blank' is taken to be a method blank. The limit of detection (LOD) is defined as the lowest concentration level that can be determined to be statistically different from a blank (Currie 1988). In general, it is

calculated as the mean of concentration in the blank plus 3 standard deviations of the blank (EPA 1987). The blank corrected LOD is simply three times the blank standard deviation. At 3 standard deviations away from the blank mean, the false positive error rate (when an analyte is declared to be present when in fact it is absent) is about 7% and the false negative error rate (when an analyte is declared to be absent when actually it is present) is about 7% (Miller and Miller 1988, p. 116).

The limit of quantitation (LOQ) is defined as the level above which quantitative results may be obtained with a specified degree of confidence (Keith 1991). It is calculated as the blank mean plus 10 standard deviations of the blank (EPA 1987). The blank corrected LOQ is 10 times the blank standard deviation. The LOQ is most useful for defining the lower limit of the useful range of concentration measurement technology. When the analyte signal is 10 times larger than the standard deviation of the blank measurements, there is a 95% probability that the true concentration of the analyte is $\pm$ 25% of the measured concentration. The LOD and LOQ are shown graphically in Figure A-1. For purpose of illustration, the numbers appearing in this figure are the respective blank mean, LOD, and LOQ for TOC (see Table A-5).

The MDL is defined as the minimum concentration of a substance that can be measured and reported with a 99% confidence that the analyte concentration is greater than 0 and is determined from analysis of a sample in a given matrix containing the analyte (Currie 1988). The MDL is 3.14 times the standard deviation of the results of 7 replicates of a low-level standard. Note that the MDL as defined above is based on the variability of the response of low-level standards rather than on the variability of the blank response.

For this RCRA annual report, only TOC and radionuclides field blanks data are available for LOD and LOQ determinations. The field blanks are quality control samples that are introduced into a process to monitor the performance of the system. The use of field blanks to calculate LOD and LOQ is preferred because they measure the errors in the entire measurement system. Methods to calculate LOD and LOQ are described in detail in DOE (1991, Appendix A). The results are shown in Tables A-5 through A-19.

Because of the lack of blanks data for other constitutes of concern, WHC deemed it is necessary to calculate approximated LOD and LOQ values using variability information obtained from low-level standards. As shown in Figure A-1, the values along the horizontal axis are measured in unit of

Figure A-1. Relationship of LOD and LOQ to Analyte Concentration.

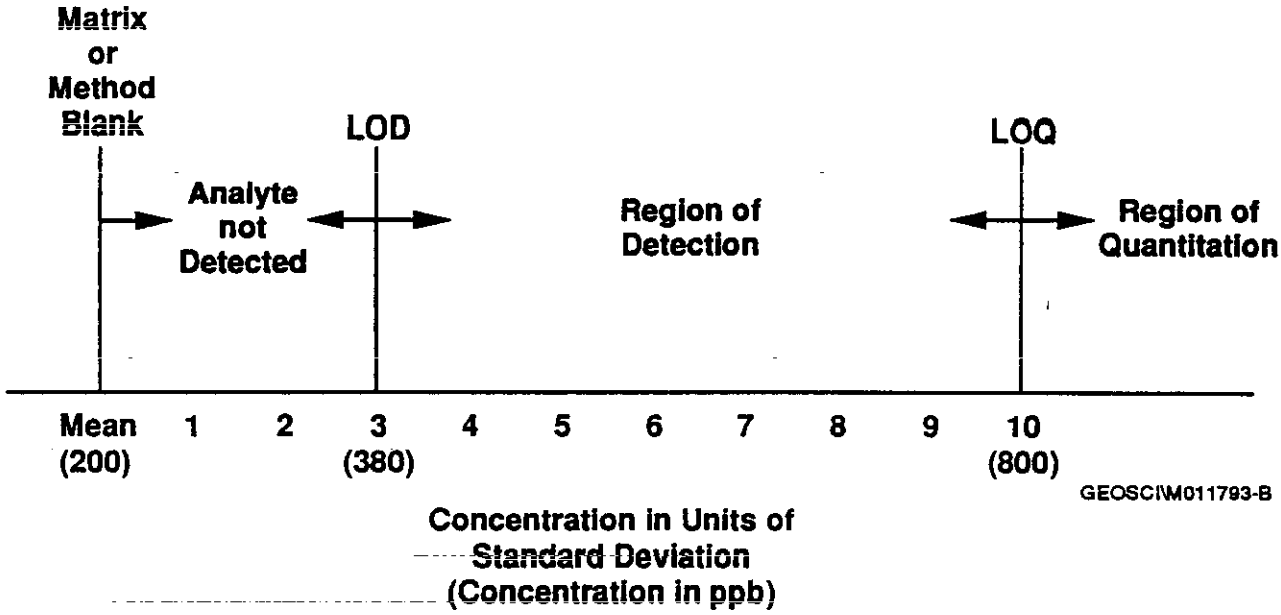

Table A-5. Groundwater Field Blanks Data From DataChem Laboratories Constituent: TOC.

Period from	Period to	Number of samples	Mean (ppb)	Standard Dev. (ppb)	LOD[a] (ppb)	LOQ[a] (ppb)
10/08/92	12/16/92	11	192.0	56.3	361	755
01/05/93	03/23/93	9[b]	225.6	72.0	442	946
04/01/93	06/24/93	9[c]	179.3	63.1	369	810
07/14/93	09/20/93	11	195.0	51.0	348	705
10/08/92	09/20/93	40	200	60	380	800

[a]LOD equals the blank mean concentration plus 3 times standard deviation and LOQ equals the blank mean concentration plus 10 times standard deviation.

[b]Excluding FTR (Full Trip Blank) #100 because it was flagged by a laboratory nonconformance report.

[c]Excluding FTR #124 because of it had blank contamination.

Table A-6. Groundwater Field Blanks Data From IT Analytical Services Constituent: Antimony-125.

Period from	Period to	Number of samples	Mean (pCi/L)	Standard Dev. (pCi/L)	LOD[a] (pCi/L)	LOQ[a] (pCi/L)
11/05/92	11/10/92	2	10.00	5.664	16.99	56.64
02/05/93	03/11/93	3	7.67	20.033	60.10	200.33
04/20/93	06/24/93	5	3.52	6.001	18.00	60.01
07/21/93	09/20/93	5	-7.54	6.081	18.24	60.81
11/05/92	09/20/93	15	1.53	10.12	30.36	101.2

[a]LOD (blank corrected) equals is 3 times blank standard deviation and LOQ (blank corrected) equals 10 times blank standard deviation.

Table A-7. Groundwater Field Blanks Data From IT Analytical Services Constituent: Cesium-137.

Period from	Period to	Number of samples	Mean (pCi/L)	Standard Dev. (pCi/L)	LOD[a] (pCi/L)	LOQ[a] (pCi/L)
11/05/92	11/10/92	2	1.87	2.269	6.81	22.69
02/05/93	03/11/93	3	-1.88	2.263	6.79	22.63
04/20/93	06/24/93	5	0.75	1.485	4.46	14.85
07/21/93	09/20/93	5	1.51	3.099	9.30	30.99
11/05/92	09/20/93	15	0.62	2.386	7.16	23.86

[a]LOD (blank corrected) equals is 3 times blank standard deviation and LOQ (blank corrected) equals 10 times blank standard deviation.

Table A-8. Groundwater Field Blanks Data From IT Analytical Services Constituent: Cobalt-60.

Period from	Period to	Number of samples	Mean (pCi/L)	Standard Dev. (pCi/L)	LOD[a] (pCi/L)	LOQ[a] (pCi/L)
11/05/92	11/10/92	2	-5.73	3.521	10.56	35.21
02/05/93	03/11/93	3	0.36	4.296	12.89	42.96
04/20/93	06/24/93	5	-1.32	6.125	18.38	61.25
07/21/93	09/20/93	5	0.54	2.579	7.74	25.79
11/05/92	09/20/93	15	-0.95	4.532	13.60	45.32

[a]LOD (blank corrected) equals is 3 times blank standard deviation and LOQ (blank corrected) equals 10 times blank standard deviation.

Table A-9. Groundwater Field Blanks Data From IT Analytical Services Constituent: Gross Alpha.

Period from	Period to	Number of samples	Mean (pCi/L)	Standard Dev. (pCi/L)	LOD[a] (pCi/L)	LOQ[a] (pCi/L)
11/08/92	12/17/92	12	-0.013	0.212	0.64	2.12
01/26/93	03/23/93	9	-0.059	0.191	0.57	1.91
04/01/93	06/24/93	12	-0.001	0.150	0.45	1.50
07/21/93	09/30/93	13	0.080	0.147	0.44	1.47
11/08/92	09/30/93	46	0.007	0.176	0.53	1.76

[a]LOD (blank corrected) equals is 3 times blank standard deviation and LOQ (blank corrected) equals 10 times blank standard deviation.

Table A-10. Groundwater Field Blanks Data From IT Analytical Services Constituent: Gross Beta.

Period from	Period to	Number of samples	Mean (pCi/L)	Standard Dev. (pCi/L)	LOD[a] (pCi/L)	LOQ[a] (pCi/L)
11/08/92	12/17/92	11	-0.007	0.602	1.80	6.02
01/26/93	03/23/93	9	-0.962	2.158	6.47	21.58
04/01/93	06/24/93	13	-0.480	0.983	2.95	9.83
07/21/93	09/30/93	13	0.093	1.027	3.08	10.27
11/08/92	09/30/93	46	-0.299	1.245	3.74	12.45

[a]LOD (blank corrected) equals is 3 times blank standard deviation and LOQ (blank corrected) equals 10 times blank standard deviation.

Table A-11. Groundwater Field Blanks Data From IT Analytical Services Constituent: Iodine-129.

Period from	Period to	Number of samples	Mean (pCi/L)	Standard Dev. (pCi/L)	LOD[a] (pCi/L)	LOQ[a] (pCi/L)
11/05/92	09/20/93	6	0.139	0.215	0.64	2.15

[a]LOD (blank corrected) equals is 3 times blank standard deviation and LOQ (blank corrected) equals 10 times blank standard deviation.

Table A-12. Groundwater Field Blanks Data From IT Analytical Services Constituent: Plutonium-238.

Period from	Period to	Number of samples	Mean (pCi/L)	Standard Dev. (pCi/L)	LOD[a] (pCi/L)	LOQ[a] (pCi/L)
11/05/92	09/20/93	5	-0.002	0.004	0.011	0.036

[a]LOD (blank corrected) equals is 3 times blank standard deviation and LOQ (blank corrected) equals 10 times blank standard deviation.

Table A-13. Groundwater Field Blanks Data From IT Analytical Services Constituent: Plutonium-239/240.

Period from	Period to	Number of samples	Mean (pCi/L)	Standard Dev. (pCi/L)	LOD[a] (pCi/L)	LOQ[a] (pCi/L)
11/05/92	09/20/93	5	0.008	0.019	0.058	0.192

[a]LOD (blank corrected) equals is 3 times blank standard deviation and LOQ (blank corrected) equals 10 times blank standard deviation.

Table A-14. Groundwater Field Blanks Data From IT Analytical Services Constituent: Radium.

Period from	Period to	Number of samples	Mean (pCi/L)	Standard Dev. (pCi/L)	LOD[a] (pCi/L)	LOQ[a] (pCi/L)
10/08/92	11/12/92	6	-0.021	0.050	0.15	0.50
01/26/93	03/23/93	7	-0.043	0.023	0.07	0.23
04/08/93	06/24/93	8	-0.040	0.028	0.08	0.28
07/22/93	09/20/93	9	0.050	0.072	0.22	0.72
10/08/92	09/20/93	30	-0.010	0.049	0.15	0.49

[a]LOD (blank corrected) equals is 3 times blank standard deviation and LOQ (blank corrected) equals 10 times blank standard deviation.

Table A-15. Groundwater Field Blanks Data From IT Analytical Services Constituent: Ruthenium-106.

Period from	Period to	Number of samples	Mean (pCi/L)	Standard Dev. (pCi/L)	LOD[a] (pCi/L)	LOQ[a] (pCi/L)
11/05/92	11/10/92	2	-20.30	8.202	24.61	82.02
02/25/93	03/11/93	3	-17.237	36.154	108.46	361.54
04/20/93	06/24/93	5	2.560	56.449	169.35	564.49
07/21/93	09/20/93	5	-3.000	47.437	142.31	474.37
11/05/92	09/20/93	15	-6.301	47.125	141.38	471.25

[a]LOD (blank corrected) equals is 3 times blank standard deviation and LOQ (blank corrected) equals 10 times blank standard deviation.

Table A-16. Groundwater Field Blanks Data From IT Analytical Services Constituent: Strontium-90.

Period from	Period to	Number of samples	Mean (pCi/L)	Standard Dev. (pCi/L)	LOD[a] (pCi/L)	LOQ[a] (pCi/L)
10/15/92	11/10/92	3	-0.303	0.061	0.182	0.607
02/25/93	03/02/93	2	-0.340	0.052	0.157	0.523
05/11/93	06/24/93	4	-0.168	0.183	0.549	1.829
08/10/93	09/20/93	3	0.102	0.110	0.330	1.101
10/15/92	09/20/93	12	-0.163	0.130	0.390	1.300

[a]LOD (blank corrected) equals is 3 times blank standard deviation and LOQ (blank corrected) equals 10 times blank standard deviation.

Table A-17. Groundwater Field Blanks Data From IT Analytical Services Constituent: Technetium-99.

Period from	Period to	Number of samples	Mean (pCi/L)	Standard Dev. (pCi/L)	LOD[a] (pCi/L)	LOQ[a] (pCi/L)
10/13/92	11/10/92	4	0.481	2.295	6.884	22.945
01/28/93	03/23/93	3	0.174	1.378	4.133	13.776
04/01/93	06/24/93	3	1.387	1.442	4.327	14.422
07/21/93	09/30/93	4	-0.194	1.116	3.347	11.157
10/13/92	09/30/93	14	0.4171	1.658	4.974	16.580

[a]LOD (blank corrected) equals is 3 times blank standard deviation and LOQ (blank corrected) equals 10 times blank standard deviation.

Table A-18. Groundwater Field Blanks Data From IT Analytical Services Constituent: Tritium.

Period from	Period to	Number of samples	Mean (pCi/L)	Standard Dev. (pCi/L)	LOD[a] (pCi/L)	LOQ[a] (pCi/L)
10/08/92	12/17/92	10	150.52	164.502	493.51	1645.02
01/26/93	03/23/93	8	158.79	167.834	503.50	1678.34
04/08/93	06/24/93	11	97.64	93.360	280.08	933.60
07/14/93	09/30/93	14	58.55	88.311	264.93	883.11
10/08/92	09/30/93	43	108.59	127.024	381.07	1270.24

[a]LOD (blank corrected) equals is 3 times blank standard deviation and LOQ (blank corrected) equals 10 times blank standard deviation.

Table A-19. Groundwater Field Blanks Data From IT Analytical Services Constituent: Uranium.

Period from	Period to	Number of samples	Mean (pCi/L)	Standard Dev. (pCi/L)	LOD[a] (pCi/L)	LOQ[a] (pCi/L)
10/08/92	11/12/92	6	0.027	0.038	0.114	0.380
01/28/93	03/02/93	4	-0.002	0.122	0.365	1.218
04/01/93	06/24/93	5	0.043	0.061	0.184	0.612
07/21/93	09/20/93	7	0.198	0.146	0.437	1.456
10/08/92	09/20/93	22	0.080	0.104	0.310	1.040

[a]LOD (blank corrected) equals is 3 times blank standard deviation and LOQ (blank corrected) equals 10 times blank standard deviation.

'standard deviation' of the measurement process (i.e., based on well-known blank). If low-level standards are used, the variability of the difference between the sample and blank response is increased by a factor of $\sqrt{2}$ (Currie 1988, p. 84). The formulas are summarized below:

$$MDL = 3.14 * s$$

$$LOD = 3 * (\sqrt{2} * s)$$
$$= 4.24 * s$$

$$LOQ = 10 * (\sqrt{2} * s)$$
$$= 14.14 * s$$

where s denotes standard deviation from the 7 replicates of the low-level standard.

The results of MDL, LOD, and LOQ calculations, for other constituents of concern, are shown in Table A-20.

A.7 QUALITY CONTROL DEFINITIONS

Accuracy--The closeness of agreement between an observed value and a true value. Accuracy is assessed by means of reference samples and percent recoveries.

Blind sample--A sample that contains a concentration of analyte that is known to the supplier but unknown to the analyzing laboratory. The analyzing laboratory is informed that the sample is a QC sample and not a field sample. The blind, the double blind, and the matrix-matched double blind samples are used to assess accuracy and monitor the performance of the analytical laboratory(ies) with prepared or purchased materials from EPA QC samples/ concentrates or primary materials.

Bottle blank--A sample that contains only Type II reagent water. The bottle blank contains one sample for each bottle size, with at least enough bottles to include all constituents analyzed by a specific project, except radionuclides. Bottle blanks shall be submitted to the primary laboratory per lot of bottles. Bottle blanks are filled in the analytical laboratory under the sample preparation procedures. Bottle blanks do <u>not</u> go into the field.

Contractually required quantitation limit--A value intended to be the lowest analyte concentration in a given matrix that the laboratory can be expected to achieve consistently; agreed upon under the contract statement of work.

Table A-20. LOD and LOQ Calculations for Selected Constituents Based on MDL Report[a,b] for LOW Level Standards. (sheet 1 of 3)

Method name	Constituent	Std Dev.	MDL	LOD	LOQ
ASTM D-2579-A	Total carbon*	101.911	320	432	1,441
ASTM D-1067-A	Alkalinity (ppm)	0.510	1.600	2.162	7.206
ASTM D-1125-A	Conductivity, lab	NA	NA	NA	NA
ASTM D-1293	pH, lab	NA	NA	NA	NA
ASTM D-1426-D	Ammonium ion	5.732	18	24	81
ASTM D-4327-88	Bromide*	35.032	110	149	495
ASTM D-4327-88	Chloride*	22.611	71	96	320
ASTM D-4327-88	Fluoride	13.694	43	58	194
ASTM D-4327-88	Nitrate	25.159	79	107	356
ASTM D-4327-88	Nitrite*	35.032	110	149	495
ASTM D-4327-88	Phosphate*	149.682	470	635	2,117
ASTM D-4327-88	Sulfate	101.911	320	432	1,441
SW-846 6010	Barium	0.510	1.6	2.2	7.2
SW-846 6010	Beryllium	0.605	1.9	2.6	8.6
SW-846 6010	Cadmium	0.510	1.6	2.2	7.2
SW-846 6010	Calcium	9.236	29	39	131
SW-846 6010	Chromium	1.911	6	8	27
SW-846 6010	Cobalt	1.369	4.3	5.8	19.4
SW-846 6010	Copper	1.879	5.9	8.0	26.6
SW-846 6010	Iron	3.185	10	14	45
SW-846 6010	Magnesium	11.783	37	50	167
SW-846 6010	Manganese	0.669	2.1	2.8	9.5
SW-846 6010	Nickel	3.503	11	15	50
SW-846 6010	Potassium	95.541	300	405	1,351
SW-846 6010	Sodium*	47.771	150	203	676
SW-846 6010	Vanadium	2.739	8.6	11.6	38.7
SW-846 6010	Zinc	1.338	4.2	5.7	18.9
SW-846 7060	Arsenic	0.131	0.41	0.55	1.85
SW-846 7421	Lead	0.541	1.7	2.3	7.7
SW-846 7470	Mercury*	0.030	0.094	0.127	0.423

Table A-20. LOD and LOQ Calculations for Selected Constituents Based on MDL Report[a,b] for LOW Level Standards. (sheet 2 of 3)

Method name	Constituent	Std Dev.	MDL	LOD	LOQ
SW-846 8010/8020	1,1,1-Trichloroethane*	0.038	0.12	0.16	0.54
SW-846 8010/8020	1,1,2-Trichloroethane*	0.029	0.09	0.12	0.41
SW-846 8010/8020	1,1-Dichloroethane*	0.057	0.18	0.24	0.81
SW-846 8010/8020	1,2-Dichlotoethane*	0.038	0.12	0.16	0.54
SW-846 8010/8020	Carbon tetrachloride*	0.048	0.15	0.20	0.68
SW-846 8010/8020	Chloroform*	0.031	0.097	0.131	0.437
SW-846 8010/8020	Tetrachloroethene*	0.051	0.16	0.22	0.72
SW-846 8010/8020	Trichloroethene*	0.032	0.10	0.14	0.45
SW-846 8010/8020	Xylenes (total)*	0.025	0.08	0.11	0.36
SW-846 8010/8020	Cis-1,2-Dichloroethylene*	0.041	0.13	0.18	0.59
SW-846 8010/8020	Trans-1,2-Dichloroethylene*	0.048	0.15	0.20	0.68
SW-846 8040	2,4,6-Trichlorophenol	0.510	1.6	2.2	7.2
SW-846 8040	2,4-Dichlorophenol	0.478	1.5	2.0	6.8
SW-846 8040	2,4-Dimethylphenol	1.306	4.1	5.5	18.5
SW-846 8040	2,6-Dichlorophenol	0.478	1.5	2.0	6.8
SW-846 8040	2-Chlorophenol	0.446	1.4	1.9	6.3
SW-846 8040	2-Nitrophenol	0.573	1.8	2.4	8.1
SW-846 8040	2-sec-Butyl-4,6-dinitrophenol(DNBP)	0.541	1.7	2.3	7.7
SW-846 8040	4-Chloro-3-methylphenol	0.860	2.7	3.6	12.2
SW-846 8040	4-Nitrophenol	1.083	3.4	4.6	15.3
SW-846 8040	Cresols	3.121	9.8	13.2	44.1
SW-846 8040	Pentachlorophenol	0.669	2.1	2.8	9.5
SW-846 8040	Phenol	0.099	0.31	0.42	1.40
SW-846 8040	Tetrachlorophenols	0.573	1.8	2.4	8.1
SW-846 8040	Trichlorophenols*	0.446	1.4	1.9	6.3
SW-846 8080	4,4'-DDD*	0.001	0.004	0.005	0.018
SW-846 8080	4,4'-DDE*	0.000	0.002	0.002	0.007
SW-846 8080	4,4'-DDT*	0.000	0.001	0.002	0.005
SW-846 8080	Aldrin	0.007	0.022	0.030	0.099
SW-846 8080	Beta-BHC*	0.000	0.001	0.002	0.006

Table A-20. LOD and LOQ Calculations for Selected Constituents Based on MDL Report[a,b] for LOW Level Standards. (sheet 3 of 3)

Method name	Constituent	Std Dev.	MDL	LOD	LOQ
SW-846 8080	Dieldrin*	0.001	0.002	0.003	0.009
SW-846 8080	Endrin*	0.001	0.004	0.006	0.019
SW-846 8080	Endrin aldehyde*	0.001	0.004	0.005	0.018
SW-846 8080	Heptachlor	0.005	0.017	0.023	0.077
SW-846 8080	Gamma-BHC (Lindane)*	0.000	0.002	0.002	0.007
SW-846 8140	Phorate	0.083	0.260	0.351	1.171
SW-846 8240	1,1,1,-Trichloroethane	1.338	4.2	5.7	18.9
SW-846 8240	1,1,2-Trichloroethane*	0.051	0.16	0.22	0.72
SW-846 8240	1,4-Dichlorobenzene	0.309	0.97	1.31	4.37
SW-846 8240	Acetone	1.433	4.5	6.1	20.3
SW-846 8240	Benzene*	0.035	0.11	0.15	0.50
SW-846 8240	Carbon disulfide	0.573	1.8	2.4	8.1
SW-846 8240	Carbon tetrachloride*	0.350	1.1	1.5	5.0
SW-846 8240	Chlorobenzene	0.261	0.82	1.11	3.69
SW-846 8240	Chloroform*	0.054	0.17	0.23	0.77
SW-846 8240	Ethylbenzene*	0.067	0.21	0.28	0.95
SW-846 8240	Methylene chloride*	0.025	0.077	0.104	0.347
SW-846 8240	Toluene*	0.038	0.12	0.16	0.54
SW-846 8240	Trichloroethene	0.264	0.83	1.12	3.74
SW-846 8240	trans-1,2-Dichloroethylene	0.048	0.15	0.20	0.68
SW-846 8270	2-Nitrophenol	1.592	5	7	23
SW-846 8270	Phenol	0.892	2.8	3.8	12.6
SW-846 8270	Tris-2-chloroethyl phosphate	2.834	8.9	12.0	NA
SW-846 9010	Cyanide	0.194	0.610	0.824	2.747
SW-846 9020	Total organic halogen	1.752	5.5	7.4	24.8
SW-846 9132	Coliforms, membrane filter[c]	NA	NA	NA	NA
Std Meth #209B	Total dissolved solids	NA	NA	NA	NA
Std Meth #214A	Turbidity (NTU)	0.006	0.02	0.03	0.09
USEPA HACH COD	Chemical oxygen demand	NA	NA	NA	NA

[a]Hazardous Chemistry Laboratory August 1993 MDL Report.
[b]In unit of ppb unless noted.
[c]Colonies/100 mL.
*Test concentration range (for the standard) is beyond 1 to 10 times the estimated MDL.

Daily trip blank--A sample that contains only Type II reagent water. The daily trip blank is used to check for sample contamination by volatile organic compounds arising from conditions encountered during the collection of samples. The daily trip blank is not opened in the field. One daily trip blank is collected for each day sampling occurs.

Double blind sample--A sample that contains a concentration of analyte that is known to the supplier but is unknown to the analyzing laboratory. The analyzing laboratory is not informed that the sample is a QC sample. All attempts are made to make this sample appear like a field sample. For example, the double blind sample should be submitted to the laboratory within the same time period and with a sample identification number similar to that of the field samples. The double blind sample does not include matrix matching.

External quality control sample--Any QC sample prepared without the knowledge of the analytical laboratory.

Field duplicate sample--A sample used to determine repeatability of an analytical measurement on identical samples collected as close as possible to the same time at the same location. These samples are stored in separate containers and are analyzed independently by the same laboratory.

Field transfer blank--A sample that contains only Type II reagent water. The blank field transfer blank is used to check for sample contamination by volatile organic compounds arising from conditions encountered during the collection of samples. The field transfer blank is taken during the collection of samples. The field transfer blank is filled at the sampling site by pouring Type II reagent water from a cleaned container into a volatile organic analysis vial. At least 1 field transfer blank is collected for each 20 samples, or 1 per sampling batch.

Full trip blank--A sample that contains only Type II reagent water and preservative, as required. A full trip blank is used to check for contamination in sample bottles and sample preparation. The full trip blank is analyzed for all constituents of interest on all types of sample bottles used during that sampling period. The frequency of collection for a full trip blank is 1 per 20 samples, or 1 per sampling batch. A full trip blank is filled in the analytical laboratory under the sample preparation procedures. The full trip blank is not opened in the field.

Internal quality control sample--Any QC sample prepared by the analytical laboratory and used to establish and monitor the quality of the analytical laboratory.

Limit of detection--The lowest concentration level that is statistically different from a blank. This is calculated by the average blank signal plus three standard deviations for the blank analyses (see Appendix B for more detail).

Matrix-matched double blind sample--A matrix-matched double blind sample contains a concentration of analyte that is known to the supplier but unknown to the analyzing laboratory. The sample matrix has been altered to closely match that of the field samples.

Method detection limit--The minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero, and is determined from analysis of a sample in a given matrix type containing the analyte.

Minimum detectable concentration--Required level of analytical detection for radiochemical samples.

Precision--The agreement among a set of individual measurements of the same property, usually under prescribed similar conditions. Precision is calculated by using relative percent difference of the duplicate/replicate analyses. These samples should contain concentrations of analyte above the MDL and may involve the use of matrix spikes.

Reliable detection level--A detection limit set at two times the concentration of the MDL, so the risk of both false positives and false negatives falls below 1%.

Type II reagent water--Distilled or deionized water that is free of contaminants that may interfere with the analytical test in question.

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APPENDIX B

DATA EVALUATION

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APPENDIX B

DATA EVALUATION

B.0 DATA EVALUATION

F. N. Hodges
Westinghouse Hanford Company

Data evaluation is a process through which suspect data are identified and/or investigated. At present, the data evaluation process consists of the investigation of Requests for Data Evaluations (RADE) and the statistical evaluation of contamination indicator parameter data.

The evaluations of RADEs are discussed in the following section. The statistical evaluation of contamination indicator parameters is discussed in the various site-specific chapters.

B.1 REQUEST FOR ANALYTICAL DATA EVALUATION PROCEDURE

Suspect data called out in RADEs are evaluated in terms of the following (WHC-CM-7-8):

- Trending of historical data for the well in question
- Variations in contaminant distributions (i.e., plumes) that may affect concentrations in the well in question
- Quality control data that may affect the data in question
- Laboratory data (i.e., chemist sheets) for the data in question.

As a result of the RADEs, the data in question may be as follows:

- Determined to be acceptable
- Determined to be in error and corrected
- Permanently flagged as suspect data
- Permanently flagged as rejected data.

B.2 REQUEST FOR ANALYTICAL DATA EVALUATIONS

A total of 156 RADEs were submitted between September 1992 and October 1993; 36 of the RADEs have been resolved. The RADEs submitted involved most of the major analytical groups; however, over three-quarters

of the total was accounted for by the following four constituent groups: (1) total organic halogen, (2) inductively coupled plasma metals, (3) field parameters, and (4) radionuclides (Figure B-1).

B.2.1 Total Organic Halogen

This constituent group received the largest number of RADEs. The RADEs for total organic halogen are clearly the result of laboratory problems, as indicated by two laboratory audits (see Appendix A). Resolution of the RADEs concerning total organic halogen await resolution of problems at the DataChem Laboratory.

B.2.2 Inductively Coupled Plasma Metals

Thirty-two RADEs for inductively coupled plasma metals address suspect values for 19 elements. There does not appear to be a systematic error and evaluation will depend on laboratory records.

B.2.3 Field Measurements

Thirty-one RADEs involve measurements of pH and conductivity made by field samplers, and usually reflect values that are unusually higher or lower than historical trends for a particular well. This represents a long-term recurrent problem with field calibration and measurement and at this time there is little that can be done other than flag the numbers as suspect data.

B.2.4 Radionuclides

Eleven RADEs were submitted concerning radionuclide analysis. These RADEs seem to represent a random collection of out-of-range data and do not indicate systematic problems with the analyses. These data are being re-evaluated by the laboratory.

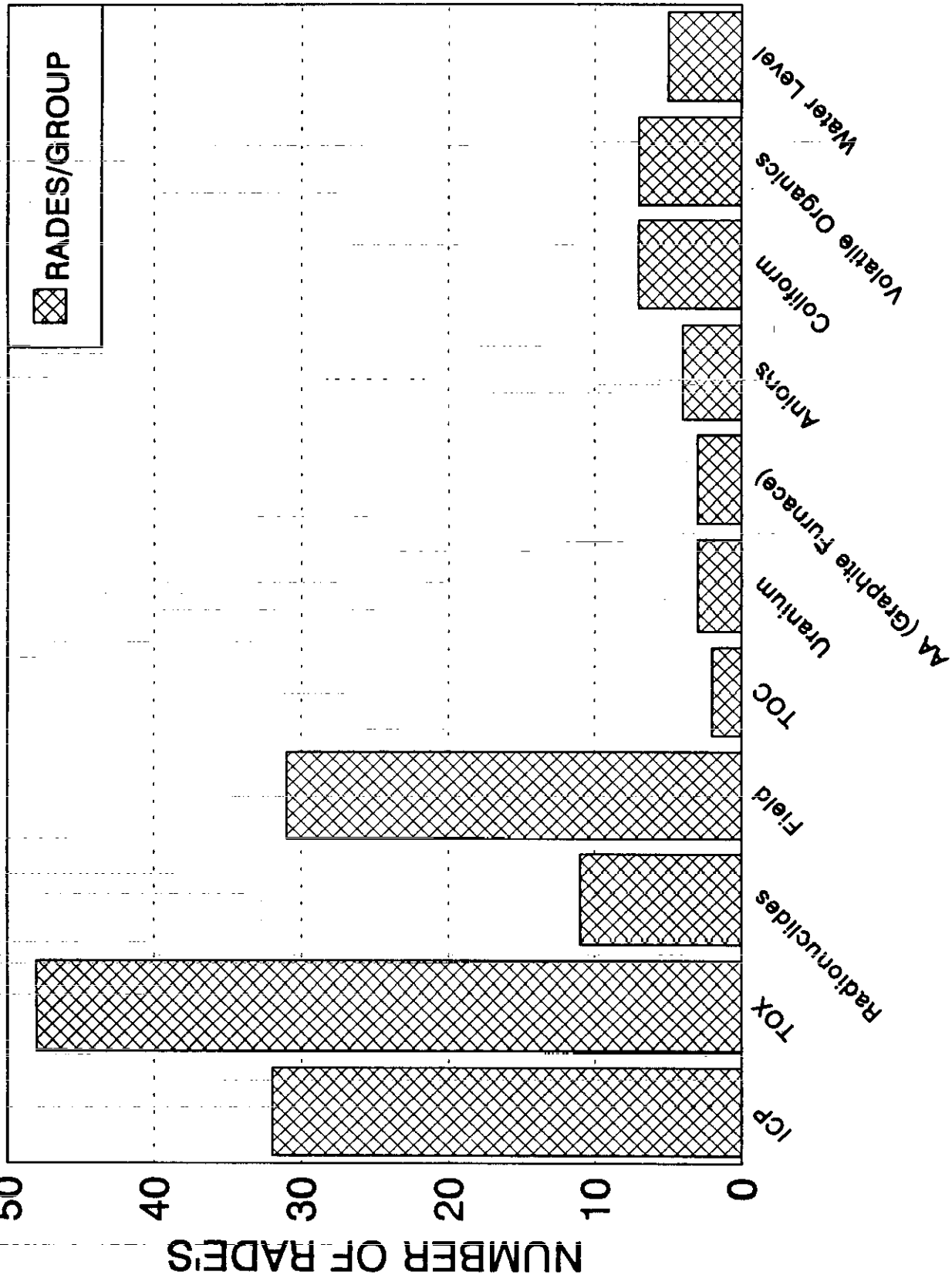
B.2.5 Others

The remainder of the categories reflect a variety of problems, most of which can be resolved only through the examination of laboratory records. Examples in this category include total organic carbon, anions, volatile organics, metals analyzed by graphite furnace AA (lead, arsenic, selenium), and ammonium.

B.3 REFERENCES

WHC-CM-7-8, *Environmental Engineering and Geotechnology Function Procedures*, Section 4.2, "Evaluation of Requests for Analytical Data Review," Westinghouse Hanford Company, Richland, Washington.

Figure B-1. Histogram Showing Number of RADEs Submitted in Different Analytical Categories.



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APPENDIX C

STATISTICS

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APPENDIX C

STATISTICS

C.0 INTRODUCTION

C. J. Chou
Westinghouse Hanford Company

Statistical evaluations for the past year consisted of: (1) establishing background levels for various *Resource Conservation and Recovery Act of 1976* (RCRA) facilities that completed collecting four quarters of monitoring data (e.g., 100-D Pond); (2) re-establishing background levels for several RCRA facilities (e.g., 1325-N and Low-Level Waste Management Area 4) to reflect changes in the groundwater flow direction and/or the installation of new upgradient well(s); (3) continuing evaluation of RCRA facilities' impact on the quality of groundwater for those facilities operated under the indicator parameter evaluation program status; and (4) required statistical evaluations for the Solid Waste Landfill (SWL). The following provides a general description of the statistical method and results of statistical evaluations for the RCRA facilities that are regulated under *Washington Administrative Code* (WAC) 173-303. The statistical method and results of statistical evaluations for the SWL are described in the SWL section of this report because the activities of the SWL are covered under WAC 173-304.

C.1 STATISTICAL METHOD

The statistical method used to summarize background data is the averaged replicate (AR) t-test method as described in Appendix B of the *Resource Conservation and Recovery Act (RCRA) Groundwater Monitoring Technical Enforcement Guidance Document (TEGD)* (EPA 1986) and Chou (1991). The AR t-test method, for each contamination indicator parameter, is calculated as:

$$t = (\bar{x}_i - \bar{x}_b)/S_b * \sqrt{1+1/n_b} \qquad (1)$$

where:

t = Test statistic
$\bar{x}_i$ = Average of replicates from the i^{th} monitoring well
$\bar{x}_b$ = Background average
S_b = Background standard deviation
n_b = Number of background replicate averages.

The Technical Enforcement Guidance Document states that there is a statistically significant indication of contamination if the test statistic is larger than the Bonferroni critical value (t_c), i.e., $t > t_c$. These Bonferroni critical values depend on the overall false-positive rate required for each sampling period (i.e., 1% for interim status), the total number of

wells in the monitoring network, and the number of degrees of freedom ($n_b - 1$) associated with the background standard deviation. Because of the nature of the test statistic in the above equation, results to be compared to background do not contribute to the estimate of the variance. The test can be reformulated, without prior knowledge of the results of the sample to be compared to background (i.e., $\bar{x}_i$), in such a way that a critical mean (CM) can be obtained:

$$CM = \bar{x}_b + t_c * S_b * \sqrt{(1+1/n_b)} \quad \text{(one-tailed)}. \qquad (2)$$

$$CM = \bar{x}_b \pm t_c * S_b * \sqrt{(1+1/n_b)} \quad \text{(two-tailed)}. \qquad (3)$$

For pH, a two-tailed CM (or critical range) is calculated and a one-tailed CM is calculated for specific conductance, total organic carbon (TOC), and total organic halogen (TOX). The CM (or range, for pH) is the value above which (or above/below in the case of pH), a compared value is determined to be statistically different from background. TOX data were not statistically evaluated because problems associated with TOX analyses (found in the November 1992 audit) have not been corrected. Statistical evaluation of TOX data will be provided when the laboratory problems are resolved.

Most of the measured values for TOC, from upgradient (background) wells, were less than the contractually required quantitation limit (CRQL) of 1,000 ppb for DataChem Laboratories. Estimates of the background standard deviations cannot be obtained because of laboratory reporting practices. Also a new hazardous chemical laboratory contract became effective during the past year. In the old contract (before April 26, 1993), these values were reported with the CRQL value followed by a 'U' qualifier. In the new contract (after April 26, 1993) results below CRQL but above the method detection limit (MDL) of 200 ppb are reported with the measured value followed by an 'L' qualifier. Results below the MDL are reported with the MDL value followed by a 'U' qualifier. The lack of estimates of background variability precludes the determination of TOC critical means for various RCRA facilities that just completed the required four quarters of background monitoring. In this case, a limit of quantitation (LOQ) will be used as the upgradient/downgradient comparison value. The LOQ for TOC was calculated to be 800 ppb using 1993 field blanks data (see Appendix A).

Finally, if the calculated critical range (for pH) was outside the chemically possible range [0, 14] or too large to be meaningful due to the requirement of using four quarters of data to establish background (e.g., 2101-M Pond, LERF), the upgradient/downgradient comparison value shall be the revised critical range using all available data. The expansion of the background data set to include more than 1 year's data provides a better estimate of background mean and background standard deviation. More importantly, it increases the number of degrees of freedom associated with the background standard deviation. Other things being equal, a smaller t_c value and a narrower critical range for pH would result. This approach is preferred as it complies with the requirements and the spirit of regulations.

C.2 RESULTS OF STATISTICAL EVALUATIONS

During the past year two RCRA facilities, single-shell tank Waste Management Areas T and TX-TY, were shifted to assessment-level monitoring program status because of elevated specific conductance found in downgradient wells 2-W10-15, 2-W10-17, and 2-W14-12, respectively. It has not been determined that the high specific conductance found in wells 2-W10-15, 2-W10-17, and 2-W14-12 is due to contamination from these two waste management areas. Influence from other sources could exist (e.g., 216-T-5 through 216-T-25 Trenches; see Johnson [1993], Figure 5-37). A single groundwater quality assessment plan was prepared and submitted to the Washington State Department of Ecology to address the possible causes for the elevated specific conductance in the downgradient wells (Caggiano and Chou 1993).

Specific conductance also exceeded the critical mean at downgradient well 2-E25-33 of the Grout Treatment Facility. Specific conductance for this well has been historically above the CM. Because no hazardous waste has been disposed at the Grout Treatment Facility, the source of the elevated specific conductance must be some other disposal site (see discussion in Section 4.4). An alternate method of monitoring specific conductance at this well is under consideration (e.g., the use of an intrawell control chart). There is no exceedance of CMs in other RCRA facilities. Detailed statistical evaluations can be found in sections designated for each RCRA facility of this report.

C.3 BACKGROUND TABLES

This section contains detailed background information for those RCRA facilities that have:

- Completed collecting the four quarters of monitoring data to establish background levels for the first time
- Revised background levels because of changes in the groundwater flow direction and/or installation of new upgradient well(s).

For each facility, three tables are provided (Tables C-1 through C-24). They are: (1) the table listing input data for background well(s); (2) the table containing background replicate averages; and (3) the table presenting the background summary statistics.

C.4 REFERENCES

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WAC 173-303, "Dangerous Waste Regulations," *Washington Administrative Code*, as amended.

WAC 173-304, "Minimum Functional Standards for Solid Waste Handling," *Washington Administrative Code*, as amended.

Table C-1. Background Contamination Indicator Parameter Data for the 100-D Pond. (page 1 of 2)

Well Name	Sample Date	Dupl. Sample Number	Specific Conductance µmho/cm 1/700w	Field pH 0.01/8.5s	TOC ppb 1000/.	TOX[P] ppb 10/.
1-D5-13	04/16/92	1	251	8.01	1000[U]	
		2	249	8.03	1000[U]	
		3	253	8.02	1000[U]	
		4	253	8.02	1000[U]	
1-D5-13	06/03/92	1	346	7.96	1000[U]	
		2	352	7.95	1000[U]	
		3	346	7.96	1000[U]	
		4	343	7.95	1000[U]	
1-D5-13	09/02/92	1	301	8.07	1000[U]	
		2	311	8.06	1000[U]	
		3	302	8.06	1000[U]	
		4	303	8.05	1000[U]	
1-D5-13	12/14/92	1	226	8.22	1000[U]	
		2	224	8.23	1000[U]	
		3	224	8.23	1000[U]	
		4	225	8.23	1000[U]	

The column headers consist of: Constituent Name; Analysis Units; and Contractual Required Quantitation Limit/Drinking Water Standard (suffix)

Suffix s = based on Secondary Maximum Contaminant Levels in 40 CFR Part 143, National Secondary Drinking Water Regulations

w = based on additional Secondary Maximum Contaminant Levels in WAC 248-54, Public Water Supplies

Data flag:

[U]denotes that analyte concentration is below CRQL. Reported values were analytical laboratories' CRQL.

[P]denotes potential problem associated with data quality. Values are not reported.

Table C-1. Background Contamination Indicator Parameter Data for the 100-D Pond. (page 2 of 2)

Well Name	Sample Date	Dupl. Sample Number	Specific Conductance µmho/cm 1/700w	Field pH 0.01/8.5s	TOC ppb 1000/.	TOX[P] ppb 10/.
1-D5-13	03/09/93	1	252	8.08	1000[U]	
		2	252	8.10	1000[U]	
		3	252	8.09	1000[U]	
		4	253	8.09	1000[U]	

The column headers consist of: Constituent Name; Analysis Units; and Contractual Required Quantitation Limit/Drinking Water Standard (suffix)

Suffix s = based on Secondary Maximum Contaminant Levels in 40 CFR Part 143, National Secondary Drinking Water Regulations

w = based on additional Secondary Maximum Contaminant Levels in WAC 248-54, Public Water Supplies

Data flag:

[U]denotes that analyte concentration is below CRQL. Reported values were analytical laboratories' CRQL.

[P]denotes potential problem associated with data quality. Values are not reported.

Table C-2. Average Replicate Statistics--Background Indicator Parameter Data for the 100-D Pond.

Constituent (Unit)	Well Name	Sample Date	n	Average	Standard Deviation	C.V. (%)
Specific Conductance (μmho/cm)	1-D5-13	04/16/92	4	251.50	1.915	0.76
	1-D5-13	06/03/92	4	346.75	3.775	1.09
	1-D5-13	09/02/92	4	304.25	4.574	1.50
	1-D5-13	12/14/92	4	224.75	0.957	0.43
	1-D5-13	03/09/92	4	252.25	0.500	0.20
Field pH	1-D5-13	04/16/92	4	8.020	0.008	0.10
	1-D5-13	06/03/92	4	7.955	0.006	0.07
	1-D5-13	09/02/92	4	8.060	0.008	0.10
	1-D5-13	12/14/92	4	8.228	0.005	0.06
	1-D5-13	03/09/92	4	8.090	0.008	0.10
TOC (ppb)	1-D5-13	04/16/92	4	500[U]	N.A.	N.A.
	1-D5-13	06/03/92	4	500[U]	N.A.	N.A.
	1-D5-13	09/02/92	4	500[U]	N.A.	N.A.
	1-D5-13	12/14/92	4	500[U]	N.A.	N.A.
	1-D5-13	03/09/93	4	500[U]	N.A.	N.A.
TOX (ppb)	1-D5-13	04/16/92	4	N.C.	N.C.	N.C.
	1-D5-13	06/03/92	4	N.C.	N.C.	N.C.
	1-D5-13	09/02/92	4	N.C.	N.C.	N.C.
	1-D5-13	12/14/92	4	N.C.	N.C.	N.C.
	1-D5-13	03/09/92	4	N.C.	N.C.	N.C.

Note: Summary statistics calculated from only those samples that had four replicate values.

[U]Numbers were calculated using values below CRQL by replacing such values with half of the respective CRQL.

N.A. = not available. C.V. = coefficient of variation.
N.C. = not calculated.

Table C-3. Background Statistics--Contamination Indicator Parameter Data for the 100-D Pond.

Constituent	Units	n	Background average	Background standard deviation	Background C.V. (%)
Specific conductance	μmhos/cm	5	275.90	48.976	17.75
Field pH		5	8.070	0.101	1.25
TOC[a]	ppb	5	500	N.C.	N.C.
TOX[b]	ppb	N.C.	N.C.	N.C.	N.C.

Note: Summary statistics calculated from only those samples that had replicate values.

[a]Background summary statistics for TOC were calculated using values below CRQL and replacing them with half of the CRQL.

[b]Background summary statistics for TOX are not calculated due to problems related to data quality.

N.C. = not calculated.

Table C-4. Background Contamination Indicator Parameter Data for the 1325-N Liquid Waste Disposal Facility.

Well Name	Sample Date	Dupl. Sample Number	Specific Conductance µmho/cm 1/700w	Field pH 0.01/8.5s	TOC ppb 1000/.	TOX[P] ppb 10/.
1-N-74	05/28/92	1	500	7.90	1000[U]	
		2	502	7.91	1000[U]	
		3	501	7.91	1000[U]	
		4	500	7.90	1000[U]	
1-N-74	08/04/92	1	513	7.93	1000[U]	
		2	512	7.92	1000[U]	
		3	513	7.93	1000[U]	
		4	512	7.92	1000[U]	
1-N-74	11/20/92	1	510	7.94	1000[U]	
		2	512	7.94	1000[U]	
		3	512	7.96	1000[U]	
		4	512	7.96	1000[U]	
1-N-74	03/24/93	1	486	8.18	1000[U]	
		2	479	8.16	1000[U]	
		3	481	8.18	1000[U]	
		4	483	8.21	1000[U]	

The column headers consist of: Constituent Name; Analysis Units; and Contractual Required Quantitation Limit/Drinking Water Standard (suffix)

Suffix s = based on Secondary Maximum Contaminant Levels in 40 CFR Part 143, National Secondary Drinking Water Regulations
w = based on additional Secondary Maximum Contaminant Levels in WAC 248-54, Public Water Supplies

Data flag:
[U]denotes that analyte concentration is below CRQL. Reported values were analytical laboratories' CRQL.

[P]denotes potential problem associated with data quality. Values are not reported.

Table C-5. Average Replicate Statistics--Background Indicator Parameter Data for the 1325-N Liquid Waste Disposal Facility.

Constituent (Unit)	Well Name	Sample Date	n	Average	Standard Deviation	C.V. (%)
Specific Conductance (μmho/cm)	1-N-74	05/28/92	4	500.75	0.957	0.19
	1-N-74	08/04/92	4	512.50	0.577	0.11
	1-N-74	11/20/92	4	511.50	1.000	0.20
	1-N-74	03/24/93	4	482.25	2.986	0.62
Field pH	1-N-74	05/28/92	4	7.905	0.006	0.07
	1-N-74	08/04/92	4	7.925	0.006	0.07
	1-N-74	11/20/92	4	7.950	0.012	0.15
	1-N-74	03/24/93	4	8.182	0.021	0.25
TOC (ppb)	1-N-74	05/28/92	4	500[U]	N.A.	N.A.
	1-N-74	08/04/92	4	500[U]	N.A.	N.A.
	1-N-74	11/20/92	4	500[U]	N.A.	N.A.
	1-N-74	03/24/93	4	500[U]	N.A.	N.A.
TOX (ppb)	1-N-74	05/28/92	4	N.C.	N.C.	N.C.
	1-N-74	08/04/92	4	N.C.	N.C.	N.C.
	1-N-74	11/20/92	4	N.C.	N.C.	N.C.
	1-N-74	03/24/93	4	N.C.	N.C.	N.C.

Note: Summary statistics calculated from only those samples that had four replicate values.

[U]Numbers were calculated using values below CRQL by replacing such values with half of the respective CRQL.

N.A. = not available. C.V. = coefficient of variation.
N.C. = not calculated.

Table C-6. Background Statistics--Contamination Indicator Parameter Data for the 1325-N Liquid Waste Disposal Facility.

Constituent	Units	n	Background average	Background standard deviation	Background C.V. (%)
Specific conductance	μmhos/cm	4	501.75	14.046	2.80
Field pH		4	7.991	0.129	1.61
TOC[a]	ppb	4	500	N.C.	N.C.
TOX[b]	ppb	N.C.	N.C.	N.C.	N.C.

Note: Summary statistics calculated from only those samples that had replicate values.

[a]Background summary statistics for TOC were calculated using values below CRQL and replacing them with half of the CRQL.

[b]Background summary statistics for TOX are not calculated due to problems related to data quality.

N.C. = not calculated.

Table C-7. Background Contamination Indicator Parameter Data for the 216-B-63 Trench. (page 1 of 5)

Well Name	Sample Date	Dupl. Sample Number	Specific Conductance µmho/cm 1/700w	Field pH 0.01/8.5s	TOC ppb 1000/.	TOX[P] ppb 10/.
2-E27-11	07/08/92	1	354	8.07	1000[U]	
		2	354	8.07	1000[U]	
		3	354	8.07	1000[U]	
		4	353	8.07	1000[U]	
2-E27-11	10/09/92	1	350	8.05	1000[U]	
		2	349	8.01	1000[U]	
		3	348	7.99	1000[U]	
		4	347	8.00	1000[U]	
2-E27-11	01/22/93	1	371	8.26	1000[U]	
		2	374	8.26	1000[U]	
		3	377	8.27	1000[U]	
		4	378	8.27	1000[U]	
2-E27-11	07/14/93	1	390	7.93	500[L]	
		2	388	7.93	500[L]	
		3	389	7.92	400[L]	
		4	389	7.91	400[L]	

The column headers consist of: Constituent Name; Analysis Units; and Contractual Required Quantitation Limit/Drinking Water Standard (suffix)

Suffix s = based on Secondary Maximum Contaminant Levels in 40 CFR Part 143, National Secondary Drinking Water Regulations

w = based on additional Secondary Maximum Contaminant Levels in WAC 248-54, Public Water Supplies

Data flag:

[U]denotes that analyte concentration is below CRQL. Reported values were analytical laboratories' CRQL.

[L]denotes that analyte concentration is above MDL but below CRQL.

[P]denotes potential problem associated with data quality. Values are not reported.

Table C-7. Background Contamination Indicator Parameter Data for the 216-B-63 Trench. (page 2 of 5)

Well Name	Sample Date	Dupl. Sample Number	Specific Conductance µmho/cm 1/700w	Field pH 0.01/8.5s	TOC ppb 1000/.	TOX[P] ppb 10/.
2-E27-8	07/14/92	1	360	7.98	1000[U]	
		2	357	7.97	1000[U]	
		3	356	7.97	1000[U]	
		4	361	7.97	1000[U]	
2-E27-8	10/15/92	1	354	7.97	1000[U]	
		2	352	7.97	1000[U]	
		3	349	7.99	1000[U]	
		4	348	7.99	1000[U]	
2-E27-8	01/22/93	1	409	7.92	1000[U]	
		2	410	7.90	1000[U]	
		3	409	7.89	1000[U]	
		4	411	7.88	1000[U]	
2-E27-8	04/20/93	1	440	6.43[R]	1000[U]	
		2	440	6.47[R]	1000[U]	
		3	439	6.52[R]	1000[U]	
		4	439	6.52[R]	1000[U]	

The column headers consist of: Constituent Name; Analysis Units; and Contractual Required Quantitation Limit/Drinking Water Standard (suffix)

Suffix s = based on Secondary Maximum Contaminant Levels in 40 CFR Part 143, National Secondary Drinking Water Regulations
w = based on additional Secondary Maximum Contaminant Levels in WAC 248-54, Public Water Supplies

Data flag:

[U]denotes that analyte concentration is below CRQL. Reported values were analytical laboratories' CRQL.

[P]denotes potential problem associated with data quality. Values are not reported.

[R]denotes data are rejected as a result of the RADE process.

Table C-7. Background Contamination Indicator Parameter Data for the 216-B-63 Trench. (page 3 of 5)

Well Name	Sample Date	Dupl. Sample Number	Specific Conductance µmho/cm 1/700w	Field pH 0.01/8.5s	TOC ppb 1000/.	TOX[P] ppb 10/.
2-E27-9	07/08/92	1	441	7.90	1000[U]	
		2	441	7.90	1000[U]	
		3	439	7.91	1000[U]	
		4	439	7.91	1000[U]	
2-E27-9	10/08/92	1	439	8.03	1000[U]	
		2	436	8.04	1000[U]	
		3	438	8.15	1000[U]	
		4	438	8.05	1000[U]	
2-E27-9	12/28/92	1	447	8.01		
		2	452	8.02		
		3	456	8.03		
		4	455	8.03		
2-E27-9	01/22/93	1	441	7.96	1000[U]	
		2	447	7.95	1000[U]	
		3	444	7.96	1000[U]	
		4	449	7.95	1000[U]	
2-E27-9	04/20/93	1	458	7.30	1000[U]	
		2	457	7.31	1000[U]	
		3	457	7.34	1000[U]	
		4	457	7.34	1000[U]	

The column headers consist of: Constituent Name; Analysis Units; and Contractual Required Quantitation Limit/Drinking Water Standard (suffix)

Suffix s = based on Secondary Maximum Contaminant Levels in 40 CFR Part 143, National Secondary Drinking Water Regulations

w = based on additional Secondary Maximum Contaminant Levels in WAC 248-54, Public Water Supplies

Data flag:

[U]denotes that analyte concentration is below CRQL. Reported values were analytical laboratories' CRQL.

[P]denotes potential problem associated with data quality. Values are not reported.

Table C-7. Background Contamination Indicator Parameter Data for the 216-B-63 Trench. (page 4 of 5)

Well Name	Sample Date	Dupl. Sample Number	Specific Conductance µmho/cm 1/700w	Field pH 0.01/8.5s	TOC ppb 1000/.	TOX[P] ppb 10/.
2-E34-10	07/17/92	1	258	8.01	1000[U]	
		2	258	8.01	1000[U]	
		3	255	8.00	1000[U]	
		4	257	8.01	1000[U]	
2-E34-10	10/20/92	1	294	7.99	1000[U]	
		2	296	7.99	1000[U]	
		3	295	8.00	1000[U]	
		4	297	7.99	1000[U]	
2-E34-10	01/22/93	1	269	8.08	1000[U]	
		2	272	8.08	1000[U]	
		3	277	8.08	1000[U]	
		4	280	8.07	1000[U]	
2-E34-10	04/20/93	1	333	7.79	1000[U]	
		2	333	7.81	1000[U]	
		3	331	7.83	1000[U]	
		4	331	7.84	1000[U]	

The column headers consist of: Constituent Name; Analysis Units; and Contractual Required Quantitation Limit/Drinking Water Standard (suffix)

Suffix s = based on Secondary Maximum Contaminant Levels in 40 CFR Part 143, National Secondary Drinking Water Regulations
w = based on additional Secondary Maximum Contaminant Levels in WAC 248-54, Public Water Supplies

Data flag:
[U]denotes that analyte concentration is below CRQL. Reported values were analytical laboratories' CRQL.

[P]denotes potential problem associated with data quality. Values are not reported.

Table C-7. Background Contamination Indicator Parameter Data for the 216-B-63 Trench. (page 5 of 5)

Well Name	Sample Date	Dupl. Sample Number	Specific Conductance µmho/cm 1/700w	Field pH 0.01/8.5s	TOC ppb 1000/.	TOX[P] ppb 10/.
2-E27-17	07/07/92	1	352	8.08	1000[U]	
		2	350	8.05	1000[U]	
		3	347	8.06	1000[U]	
		4	350	8.05	1000[U]	
2-E27-17	10/09/92	1	326	7.93	1000[U]	
		2	329	7.95	1000[U]	
		3	329	7.93	1000[U]	
		4	329	7.98	1000[U]	
2-E27-17	01/22/93	1	308	8.40	1000[U]	
		2	309	8.28	1000[U]	
		3	312	8.24	1000[U]	
		4	314	8.22	1000[U]	
2-E27-17	04/20/93	1	352	7.91	1000[U]	
		2	352	7.91	1000[U]	
		3	352	7.92	1000[U]	
		4	352	7.91	1000[U]	

The column headers consist of: Constituent Name; Analysis Units; and Contractual Required Quantitation Limit/Drinking Water Standard (suffix)

Suffix s = based on Secondary Maximum Contaminant Levels in 40 CFR Part 143, National Secondary Drinking Water Regulations

w = based on additional Secondary Maximum Contaminant Levels in WAC 248-54, Public Water Supplies

Data flag:

[U] denotes that analyte concentration is below CRQL. Reported values were analytical laboratories' CRQL.

[P] denotes potential problem associated with data quality. Values are not reported.

Table C-8. Average Replicate Statistics--Background Indicator Parameter Data for the 216-B-63 Trench. (page 1 of 5)

Constituent (Unit)	Well Name	Sample Date	n	Average	Standard Deviation	C.V. (%)
Specific Conductance (μmho/cm)	2-E27-11	07/08/92	4	353.75	0.500	0.14
	2-E27-11	10/09/92	4	348.50	1.291	0.37
	2-E27-11	01/22/93	4	375.00	3.162	0.84
	2-E27-11	07/14/93	4	389.00	0.816	0.21
Field pH	2-E27-11	07/08/92	4	8.070	0	0
	2-E27-11	10/09/92	4	8.012	0.026	0.33
	2-E27-11	01/22/93	4	8.265	0.006	0.07
	2-E27-11	07/14/93	4	7.922	0.010	0.12
TOC (ppb)	2-E27-11	07/08/92	4	500[U]	N.A.	N.A.
	2-E27-11	10/09/92	4	500[U]	N.A.	N.A.
	2-E27-11	01/22/93	4	500[U]	N.A.	N.A.
	2-E27-11	07/14/93	4	450[L]	57.735	12.83
TOX (ppb)	2-E27-11	07/08/92	4	N.C.	N.C.	N.C.
	2-E27-11	10/09/92	4	N.C.	N.C.	N.C.
	2-E27-11	01/22/93	4	N.C.	N.C.	N.C.
	2-E27-11	07/14/93	4	N.C.	N.C.	N.C.

Note: Summary statistics calculated from only those samples that had four replicate values.

[U]Numbers were calculated using values below CRQL by replacing such values with half of the respective CRQL.

[L]denotes analyte concentration is above MDL but below CRQL.

N.A. = not available. C.V. = coefficient of variation.
N.C. = not calculated.

Table C-8. Average Replicate Statistics--Background Indicator Parameter Data for the 216-B-63 Trench. (page 2 of 5)

Constituent (Unit)	Well Name	Sample Date	n	Average	Standard Deviation	C.V. (%)
Specific Conductance (μmho/cm)	2-E27-8	07/14/92	4	358.50	2.380	0.66
	2-E27-8	10/15/92	4	350.75	2.754	0.79
	2-E27-8	01/22/93	4	409.75	0.957	0.23
	2-E27-8	04/20/93	4	439.50	0.577	0.13
Field pH	2-E27-8	07/14/92	4	7.972	0.005	0.06
	2-E27-8	10/15/92	4	7.980	0.012	0.14
	2-E27-8	01/22/93	4	7.898	0.017	0.22
	2-E27-8	04/20/93	4	6.485[R]	0.044[R]	0.67[R]
TOC (ppb)	2-E27-8	07/14/92	4	500[U]	N.A.	N.A.
	2-E27-8	10/15/92	4	500[U]	N.A.	N.A.
	2-E27-8	01/22/93	4	500[U]	N.A.	N.A.
	2-E27-8	04/20/93	4	500[U]	N.A.	N.A.
TOX (ppb)	2-E27-8	07/14/92	4	N.C.	N.C.	N.C.
	2-E27-8	10/15/92	4	N.C.	N.C.	N.C.
	2-E27-8	01/22/93	4	N.C.	N.C.	N.C.
	2-E27-8	04/20/93	4	N.C.	N.C.	N.C.

Note: Summary statistics calculated from only those samples that had four replicate values.

[U]Numbers were calculated using values below CRQL by replacing such values with half of the respective CRQL.

[R]Data are rejected as a result of the RADE process. Data will not be used to calculate the background summary statistics.

N.A. = not available. C.V. = coefficient of variation.
N.C. = not calculated.

Table C-8. Average Replicate Statistics--Background Indicator Parameter Data for the 216-B-63 Trench. (page 3 of 5)

Constituent (Unit)	Well Name	Sample Date	n	Average	Standard Deviation	C.V. (%)
Specific Conductance (μmho/cm)	2-E27-9	07/08/92	4	440.00	1.155	0.26
	2-E27-9	10/08/92	4	437.75	1.258	0.29
	2-E27-9	12/28/92	4	452.50	4.042	0.89
	2-E27-9	01/22/93	4	445.25	3.500	0.79
	2-E27-9	04/20/93	4	457.25	0.500	0.11
Field pH	2-E27-9	07/08/92	4	7.905	0.006	0.07
	2-E27-9	10/08/92	4	8.068	0.056	0.69
	2-E27-9	12/28/92	4	8.022	0.010	0.12
	2-E27-9	01/22/93	4	7.955	0.006	0.07
	2-E27-9	04/20/93	4	7.322	0.021	0.28
TOC (ppb)	2-E27-9	07/08/92	4	500[U]	N.A.	N.A.
	2-E27-9	10/08/92	4	500[U]	N.A.	N.A.
	2-E27-9	01/22/93	4	500[U]	N.A.	N.A.
	2-E27-9	04/20/93	4	500[U]	N.A.	N.A.
TOX (ppb)	2-E27-9	07/08/92	4	N.C.	N.C.	N.C.
	2-E27-9	10/08/92	4	N.C.	N.C.	N.C.
	2-E27-9	01/22/93	4	N.C.	N.C.	N.C.
	2-E27-9	04/20/93	4	N.C.	N.C.	N.C.

Note: Summary statistics calculated from only those samples that had four replicate values.

[U]Numbers were calculated using values below CRQL by replacing such values with half of the respective CRQL.

N.A. = not available. C.V. = coefficient of variation.
N.C. = not calculated.

Table C-8. Average Replicate Statistics--Background Indicator Parameter Data for the 216-B-63 Trench. (page 4 of 5)

Constituent (Unit)	Well Name	Sample Date	n	Average	Standard Deviation	C.V. (%)
Specific Conductance (μmho/cm)	2-E34-10	07/17/92	4	257.00	1.414	0.55
	2-E34-10	10/20/92	4	295.50	1.291	0.44
	2-E34-10	01/22/93	4	274.50	4.933	1.80
	2-E34-10	04/20/93	4	332.00	1.155	0.35
Field pH	2-E34-10	07/17/92	4	8.008	0.005	0.06
	2-E34-10	10/20/92	4	7.992	0.005	0.06
	2-E34-10	01/22/93	4	8.078	0.005	0.06
	2-E34-10	04/20/93	4	7.818	0.022	0.28
TOC (ppb)	2-E34-10	07/17/92	4	500[U]	N.A.	N.A.
	2-E34-10	10/20/92	4	500[U]	N.A.	N.A.
	2-E34-10	01/22/93	4	500[U]	N.A.	N.A.
	2-E34-10	04/20/93	4	500[U]	N.A.	N.A.
TOX (ppb)	2-E34-10	07/17/92	4	N.C.	N.C.	N.C.
	2-E34-10	10/20/92	4	N.C.	N.C.	N.C.
	2-E34-10	01/22/93	4	N.C.	N.C.	N.C.
	2-E34-10	04/20/93	4	N.C.	N.C.	N.C.

Note: Summary statistics calculated from only those samples that had four replicate values.

[U]Numbers were calculated using values below CRQL by replacing such values with half of the respective CRQL.

N.A. = not available. C.V. = coefficient of variation.
N.C. = not calculated.

Table C-8. Average Replicate Statistics--Background Indicator Parameter Data for the 216-B-63 Trench. (page 5 of 5)

Constituent (Unit)	Well Name	Sample Date	n	Average	Standard Deviation	C.V. (%)
Specific Conductance (μmho/cm)	2-E27-17	07/07/92	4	349.75	2.062	0.59
	2-E27-17	10/09/92	4	328.50	1.500	0.46
	2-E27-17	01/22/93	4	310.75	2.754	0.89
	2-E27-17	04/20/93	4	352.00	0	0
Field pH	2-E27-17	07/07/92	4	8.060	0.014	0.18
	2-E27-17	10/09/92	4	7.948	0.024	0.30
	2-E27-17	01/22/93	4	8.285	0.081	0.97
	2-E27-17	04/20/93	4	7.912	0.005	0.06
TOC (ppb)	2-E27-17	07/07/92	4	500[U]	N.A.	N.A.
	2-E27-17	10/09/92	4	500[U]	N.A.	N.A.
	2-E27-17	01/22/93	4	500[U]	N.A.	N.A.
	2-E27-17	04/20/93	4	500[U]	N.A.	N.A.
TOX (ppb)	2-E27-17	07/07/92	4	N.C.	N.C.	N.C.
	2-E27-17	10/09/92	4	N.C.	N.C.	N.C.
	2-E27-17	01/22/93	4	N.C.	N.C.	N.C.
	2-E27-17	04/20/93	4	N.C.	N.C.	N.C.

Note: Summary statistics calculated from only those samples that had four replicate values.

[U]Numbers were calculated using values below CRQL by replacing such values with half of the respective CRQL.

N.A. = not available. C.V. = coefficient of variation.
N.C. = not calculated.

Table C-9. Background Statistics--Contamination Indicator Parameter Data for the 216-B-63 Trench.

Constituent	Units	n	Background average	Background standard deviation	Background C.V. (%)
Specific conductance	µmhos/cm	21	369.393	60.192	16.29
Field pH		20	7.975	0.190	2.38
TOC[a]	ppb	20	500	N.C.	N.C.
TOX[b]	ppb	N.C.	N.C.	N.C.	N.C.

Note: Summary statistics calculated from only those samples that had replicate values.

[a]Background summary statistics for TOC were calculated using values below CRQL and replacing them with half of the CRQL.

[b]Background summary statistics for TOX are not calculated due to problems related to data quality.

N.C. = not calculated.

Table C-10. Background Contamination Indicator Parameter Data for the Low-Level Waste Management Area 4. (page 1 of 4)

Well Name	Sample Date	Dupl. Sample Number	Specific Conductance µmho/cm 1/700w	Field pH 0.01/8.5s	TOC ppb 1000/.	TOX ppb 10/.
2-W15-16	10/06/88	1	552	7.70	500#	2,030*
		2	552	7.70	500#	1,510*
		3	551	7.70	600#	96*
		4	551	7.70	500#	2,760*
2-W15-16	12/29/88	1	419	7.00	400#	4,670
		2	417	7.10	400#	5,310
		3	419	7.10	500#	4,380
		4	417	7.00	500#	5.130
2-W15-16	05/09/89	1	531	7.70	800#	3,500
		2			800#	3,590
		3			600#	3,920
		4			700#	3,280
2-W15-16	07/25/89	1	575	7.75	600#	6,110
		2	567	7.74	600#	6,390
		3	570	7.75	600#	5,940
		4	576	7.74	600#	6,860

The column headers consist of: Constituent Name; Analysis Units; and Contractual Required Quantitation Limit/Drinking Water Standard (suffix)

Suffix s = based on Secondary Maximum Contaminant Levels in 40 CFR Part 143, National Secondary Drinking Water Regulations
w = based on additional Secondary Maximum Contaminant Levels in WAC 248-54, Public Water Supplies

Data flag:
#denotes that analyte concentration is below CRDL. Reported values were U.S. Testing Inc.'s actual measured concentrations.

*Data point is inconsistent with replicate sample values.

Table C-10. Background Contamination Indicator Parameter Data for the Low-Level Waste Management Area 4. (page 2 of 4)

Well Name	Sample Date	Dupl. Sample Number	Specific Conductance µmho/cm 1/700w	Field pH 0.01/8.5s	TOC ppb 1000/.	TOX ppb 10/.
2-W15-18	10/06/88	1	357	7.70	400#	1,610
		2	357	7.70	400#	1,490
		3	357	7.70	300#	1,310
		4	357	7.70	400#	1,280
2-W15-18	12/30/88	1	282	8.00	300#	1,740
		2	281	7.80	300#	1,690
		3	282	7.80	300#	1,310
		4	281	7.90	400#	1,770
2-W15-18	05/15/89	1	361	7.67	400#	1,260
		2	361	7.67	500#	1,360
		3	360	7.63	400#	1,150
		4	362	7.64	400#	1,340
2-W15-18	07/11/89	1	379	7.79	600#	1,100
		2	379	7.80	600#	1,120
		3	379	7.79	500#	1,080
		4	380	7.80	400#	1,150

The column headers consist of: Constituent Name; Analysis Units; and Contractual Required Quantitation Limit/Drinking Water Standard (suffix)

Suffix s = based on Secondary Maximum Contaminant Levels in 40 CFR Part 143, National Secondary Drinking Water Regulations
w = based on additional Secondary Maximum Contaminant Levels in WAC 248-54, Public Water Supplies

Data flag:
#denotes that analyte concentration is below CRDL. Reported values were U.S. Testing Inc.'s actual measured concentrations.

Table C-10. Background Contamination Indicator Parameter Data for the Low-Level Waste Management Area 4. (page 3 of 4)

Well Name	Sample Date	Dupl. Sample Number	Specific Conductance µmho/cm 1/700w	Field pH 0.01/8.5s	TOC ppb 1000/.	TOX ppb 10/.
2-W18-24	10/07/88	1	216	7.60	400#	266
		2	216	7.60	400#	30
		3	217	7.60	400#	168
		4	216	7.60	400#	28
2-W18-24	01/04/89	1	279	7.70	400#	695
		2	279	7.80	300#	716
		3	279	7.80	400#	752
		4	279	7.80	400#	631
2-W18-24	05/11/89	1	256	7.70	200#	831
		2	256	7.70	300#	843
		3	258	7.70	300#	761
		4	257	7.70	200#	728
2-W18-24	07/28/89	1	260	7.90	800#	527
		2	260	7.85	900#	529
		3	260	7.85	700#	499
		4	260	7.85	600#	467

The column headers consist of: Constituent Name; Analysis Units; and Contractual Required Quantitation Limit/Drinking Water Standard (suffix)

Suffix s = based on Secondary Maximum Contaminant Levels in 40 CFR Part 143, National Secondary Drinking Water Regulations
w = based on additional Secondary Maximum Contaminant Levels in WAC 248-54, Public Water Supplies

Data flag:
#denotes that analyte concentration is below CRDL. Reported values were U.S. Testing Inc.'s actual measured concentrations.

Table C-10. Background Contamination Indicator Parameter Data for the Low-Level Waste Management Area 4. (page 4 of 4)

Well Name	Sample Date	Dupl. Sample Number	Specific Conductance µmho/cm 1/700w	Field pH 0.01/8.5s	TOC ppb 1000/.	TOX[P] ppb 10/.
2-W18-32	11/18/92	1	241	8.10	1000[U]	
		2	239	8.09	1000[U]	
		3	236	8.09	1000[U]	
		4	236	8.09	1000[U]	
2-W18-32	02/12/93	1	111	8.24	1000[U]	
		2	112	8.22	1000[U]	
		3	118	8.22	1000[U]	
		4	118	8.20	1000[U]	
2-W18-32	05/18/93	1	217	8.09	600[LB]	
		2	216	8.07	500[LB]	
		3	217	8.07	500[LB]	
		4	217	8.06	600[LB]	
2-W18-32	08/26/93	1	225	7.92	300[L]	
		2	225	7.93	300[L]	
		3	224	7.92	300[L]	
		4	225	7.92	400[L]	

The column headers consist of: Constituent Name; Analysis Units; and Contractual Required Quantitation Limit/Drinking Water Standard (suffix)

Suffix s = based on Secondary Maximum Contaminant Levels in 40 CFR Part 143, National Secondary Drinking Water Regulations
w = based on additional Secondary Maximum Contaminant Levels in WAC 248-54, Public Water Supplies

Data flag:
[U]denotes that analyte concentration is below CRQL. Reported values were analytical laboratories' CRQL.

[L]denotes that analyte concentration is above MDL but below CRQL.

[B]denotes that blank associated with analyte is contaminated.

[P]denotes potential probelm associated with data quality. Values are not reported.

Table C-11. Average Replicate Statistics--Background Indicator Parameter Data for the Low-Level Waste Management Area 4. (page 1 of 4)

Constituent (Unit)	Well Name	Sample Date	n	Average	Standard Deviation	C.V. (%)
Specific Conductance (μmho/cm)	2-W15-16	10/06/88	4	551.50	0.577	0.10
	2-W15-16	12/29/88	4	418.00	1.155	0.28
	2-W15-16	05/09/89	1	531.00	N.A.	N.A.
	2-W15-16	07/25/89	4	572.00	4.243	0.74
Field pH	2-W15-16	10/06/88	4	7.700	0	0
	2-W15-16	12/29/88	4	7.050	0.058	0.82
	2-W15-16	05/09/89	1	7.700	N.A.	N.A.
	2-W15-16	07/25/89	4	7.745	0.006	0.07
TOC (ppb)	2-W15-16	10/06/88	4	525#	50.000	9.52
	2-W15-16	12/29/88	4	450#	57.735	12.83
	2-W15-16	05/09/89	4	725#	95.743	13.21
	2-W15-16	07/25/89	4	600#	0	0
TOX (ppb)	2-W15-16	10/06/88	4	1,599*	1,125.55*	70.4*
	2-W15-16	12/29/88	4	4,872.5	424.765	8.72
	2-W15-16	05/09/89	4	3,572.5	265.754	7.44
	2-W15-16	07/25/89	4	6,325.0	402.037	6.36

#denotes that analyte concentration is below CRDL. Reported values were U.S. Testing Inc.'s actual measured concentrations.

*denotes numbers were calculated using inconsistent replicate values. The replicate average is not used in calculating background summary statistics.

N.A. = not available. C.V. = coefficient of variation.
N.C. = not calculated.

Table C-11. Average Replicate Statistics--Background Indicator Parameter Data for the Low-Level Waste Management Area 4. (page 2 of 4)

Constituent (Unit)	Well Name	Sample Date	n	Average	Standard Deviation	C.V. (%)
Specific Conductance (μmho/cm)	2-W15-18	10/06/88	4	357.00	0	0
	2-W15-18	12/30/88	4	281.50	0.577	0.21
	2-W15-18	05/15/89	4	361.00	0.817	0.23
	2-W15-18	07/11/89	4	379.25	0.500	0.13
Field pH	2-W15-18	10/06/88	4	7.700	0	0
	2-W15-18	12/30/88	4	7.875	0.096	1.22
	2-W15-18	05/15/89	4	7.652	0.021	0.27
	2-W15-18	07/11/89	4	7.795	0.006	0.07
TOC (ppb)	2-W15-18	10/06/88	4	375#	50.000	13.33
	2-W15-18	12/30/88	4	325#	50.000	15.38
	2-W15-18	05/15/89	4	425#	50.000	11.76
	2-W15-18	07/11/89	4	525#	95.743	18.24
TOX (ppb)	2-W15-18	10/06/88	4	1,422.5	155.644	10.94
	2-W15-18	12/30/88	4	1,627.5	214.223	13.16
	2-W15-18	05/15/89	4	1,277.5	95.350	7.46
	2-W15-18	07/11/89	4	1,112.5	29.861	2.68

#denotes that analyte concentration is below CRDL. Reported values were U.S. Testing Inc.'s actual measured concentrations.

N.A. = not available. C.V. = coefficient of variation.
N.C. = not calculated.

Table C-11. Average Replicate Statistics--Background Indicator Parameter Data for the Low-Level Waste Management Area 4. (page 3 of 4)

Constituent (Unit)	Well Name	Sample Date	n	Average	Standard Deviation	C.V. (%)
Specific Conductance (μmho/cm)	2-W18-24	10/07/88	4	216.25	0.500	0.23
	2-W18-24	01/04/89	4	279.00	0	0
	2-W18-24	05/11/89	4	256.75	0.957	0.37
	2-W18-24	07/28/89	4	260.00	0	0
Field pH	2-W18-24	10/07/88	4	7.600	0	0
	2-W18-24	01/04/89	4	7.775	0.050	0.64
	2-W18-24	05/11/89	4	7.700	0	0
	2-W18-24	07/28/89	4	7.862	0.025	0.32
TOC (ppb)	2-W18-24	10/07/88	4	400#	0	0
	2-W18-24	01/04/89	4	375#	50.000	13.33
	2-W18-24	05/11/89	4	250#	57.735	23.09
	2-W18-24	07/28/89	4	750#	129.099	17.21
TOX (ppb)	2-W18-24	10/07/88	4	123.00	115.684	94.05
	2-W18-24	01/04/89	4	698.50	50.784	7.27
	2-W18-24	05/11/89	4	790.75	55.295	6.99
	2-W18-24	07/28/89	4	505.50	29.092	5.76

#denotes that analyte concentration is below CRDL. Reported values were U.S. Testing Inc.'s actual measured concentrations.

N.A. = not available. C.V. = coefficient of variation.
N.C. = not calculated.

Table C-11. Average Replicate Statistics--Background Indicator Parameter Data for the Low-Level Waste Management Area 4. (page 4 of 4)

Constituent (Unit)	Well Name	Sample Date	n	Average	Standard Deviation	C.V. (%)
Specific Conductance (μmho/cm)	2-W18-32	11/18/92	4	238.00	2.450	1.03
	2-W18-32	02/12/93	4	114.75	3.775	3.29
	2-W18-32	05/18/93	4	216.75	0.500	0.23
	2-W18-32	08/26/93	4	224.75	0.500	0.22
Field pH	2-W18-32	11/18/92	4	8.092	0.005	0.06
	2-W18-32	02/12/93	4	8.220	0.016	0.20
	2-W18-32	05/18/93	4	8.072	0.013	0.16
	2-W18-32	08/26/93	4	7.923	0.005	0.06
TOC (ppb)	2-W18-32	11/18/92	4	500[U]	N.A.	N.A.
	2-W18-32	02/12/93	4	500[U]	N.A.	N.A.
	2-W18-32	05/18/93	4	550[BL]	57.735	10.50
	2-W18-32	08/26/93	4	325[L]	50.000	15.38
TOX (ppb)	2-W18-32	11/18/92	4	N.C.	N.C.	N.C.
	2-W18-32	02/12/93	4	N.C.	N.C.	N.C.
	2-W18-32	05/18/93	4	N.C.	N.C.	N.C.
	2-W18-32	08/26/93	4	N.C.	N.C.	N.C.

[U]denotes that analyte concentration is below CRQL. Reported values were analytical laboratories' CRQL.

[L]denotes that analyte concentration is above MDL but below CRQL.

[B]denotes that blank associated with analyte is contaminated. Replicate average is not used in calculating the background summary statistics.

N.A. = not available. C.V. = coefficient of variation.
N.C. = not calculated.

Table C-12. Background Statistics--Contamination Indicator Parameter Data for the Low-Level Waste Management Area 4.

Constituent	Units	n	Background average	Background standard deviation	Background C.V. (%)
Specific conductance	µmhos/cm	16	328.594	133.345	40.58
Field pH		16	7.779	0.261	3.36
TOC[a]	ppb	15[c]	470	142.428	30.30
TOX[b]	ppb	11[d]	2,029.796	2,002.864	98.67

[a]Background summary statistics for TOC were calculated using values below CRDL and CRQL.

[b]Background summary statistics for TOX are calculated using data analyzed by U.S. Testing Inc. of Richland.

[c]Excluding replicate average where blank associated with samples was contaminated (well 2-W18-32, 5/18/93).

[d]Excluding inconsistent replicate average from well 2-W15-16 for samples collected on 10/6/88.

N.C. = not calculated.

Table C-13. Background Contamination Indicator Parameter Data for the Low-Level Waste Management Area 5. (page 1 of 6)

Well Name	Sample Date	Dupl. Sample Number	Specific Conductance µmho/cm 1/700w	Field pH 0.01/8.5s	TOC ppb 1000/.	TOX[P] ppb 10/.
2-W6-2	05/21/92	1	353	8.03	1000[U]	
		2	358	8.02	1000[U]	
		3	359	8.01	1000[U]	
		4	358	8.00	1000[U]	
2-W6-2	08/07/92	1	309	8.09	1000[U]	
		2				
		3				
		4				
2-W6-2	12/08/92	1	388	7.99	1000[U]	
		2	389	7.99	1000[U]	
		3	389	7.97	1000[U]	
		4	389	7.96	1000[U]	
2-W6-2	02/05/93	1	396	7.88	1000[U]	
		2	396	7.87	1000[U]	
		3	397	7.87	1000[U]	
		4	398	7.88	1000[U]	
2-W6-2	05/18/93	1	392	7.89	700[LB]	
		2	390	7.87	700[LB]	
		3	389	7.85	600[LB]	
		4	393	7.84	600[LB]	

The column headers consist of: Constituent Name; Analysis Units; and Contractual Required Quantitation Limit/Drinking Water Standard (suffix)

Suffix s = based on Secondary Maximum Contaminant Levels in 40 CFR Part 143, National Secondary Drinking Water Regulations

w = based on additional Secondary Maximum Contaminant Levels in WAC 248-54, Public Water Supplies

Data flag:

[U]denotes that analyte concentration is below CRQL. Reported values were analytical laboratories' CRQL.

[L]denotes that analyte concentration is above MDL but below CRQL.

[B]denotes that blank associated with analyte is contaminated.

[P]denotes potential problem associated with data quality. Values are not reported.

Table C-13. Background Contamination Indicator Parameter Data for the Low-Level Waste Management Area 5. (page 2 of 6)

Well Name	Sample Date	Dupl. Sample Number	Specific Conductance µmho/cm 1/700w	Field pH 0.01/8.5s	TOC ppb 1000/.	TOX[P] ppb 10/.
2-W6-4	09/04/92	1	580	8.10	1000[U]	
		2	582	8.09	1000[U]	
		3	579	8.08	1000[U]	
		4	580	8.07	1000[U]	
2-W6-4	12/08/92	1	635	8.29	1000[U]	
		2	635	8.28	1000[U]	
		3	635	8.28	1000[U]	
		4	635	8.28	1000[U]	
2-W6-4	03/17/93	1	571	8.55	1000[U]	
		2	570	8.55	1000[U]	
		3	560	8.48	1000[U]	
		4	572	8.49	1000[U]	
2-W6-4	06/10/93	1	550	8.14	600[LB]	
		2	552	8.10	600[LB]	
		3	554	8.09	300[LB]	
		4	557	8.07	300[L]	

The column headers consist of: Constituent Name; Analysis Units; and Contractual Required Quantitation Limit/Drinking Water Standard (suffix)

Suffix s = based on Secondary Maximum Contaminant Levels in 40 CFR Part 143, National Secondary Drinking Water Regulations
w = based on additional Secondary Maximum Contaminant Levels in WAC 248-54, Public Water Supplies

Data flag:

[U]denotes that analyte concentration is below CRQL. Reported values were analytical laboratories' CRQL.

[L]denotes that analyte concentration is above MDL but below CRQL.

[B]denotes that blank associated with analyte is contaminated.

[P]denotes potential problem associated with data quality. Values are not reported.

Table C-13. Background Contamination Indicator Parameter Data for the Low-Level Waste Management Area 5. (page 3 of 6)

Well Name	Sample Date	Dupl. Sample Number	Specific Conductance µmho/cm 1/700w	Field pH 0.01/8.5s	TOC ppb 1000/.	TOX[P] ppb 10/.
2-W6-9	12/08/92	1	428	8.01	1000[U]	
		2	429	8.01	1000[U]	
		3	427	8.00	1000[U]	
		4	427	8.00	1000[U]	
2-W6-9	03/15/93	1	446	7.95	1000[U]	
		2	447	7.96	1000[U]	
		3	448	7.95	1000[U]	
		4	449	7.95	1000[U]	
2-W6-9	06/14/93	1	450	7.70	500[LB]	
		2	448	7.68	400[LB]	
		3	448	7.67	400[LB]	
		4	447	7.66	400[LB]	
2-W6-9	09/10/93	1	425	7.77	300[L]	
		2	424	7.79	400[L]	
		3	420	7.77	400[L]	
		4	424	7.77	400[L]	

The column headers consist of: Constituent Name; Analysis Units; and Contractual Required Quantitation Limit/Drinking Water Standard (suffix)

Suffix s = based on Secondary Maximum Contaminant Levels in 40 CFR Part 143, National Secondary Drinking Water Regulations
w = based on additional Secondary Maximum Contaminant Levels in WAC 248-54, Public Water Supplies

Data flag:

[U]denotes that analyte concentration is below CRQL. Reported values were analytical laboratories' CRQL.

[L]denotes that analyte concentration is above MDL but below CRQL.

[B]denotes that blank associated with analyte is contaminated.

[P]denotes potential problem associated with data quality. Values are not reported.

Table C-13. Background Contamination Indicator Parameter Data for the Low-Level Waste Management Area 5. (page 4 of 6)

Well Name	Sample Date	Dupl. Sample Number	Specific Conductance µmho/cm 1/700w	Field pH 0.01/8.5s	TOC ppb 1000/.	TOX[P] ppb 10/.
2-W6-10	12/08/92	1	759	7.88	1000[U]	
		2	752	7.90	1000[U]	
		3	751	7.92	1000[U]	
		4	753	7.94	1000[U]	
2-W6-10	03/22/93	1	730	7.73	1000[U]	
		2	732	7.75	1000[U]	
		3	730	7.75	1000[U]	
		4	737	7.76	1000[U]	
2-W6-10	06/14/93	1	750	7.66	700[LB]	
		2	748	7.62	700[LB]	
		3	747	7.60	400[LB]	
		4	747	7.60	500[LB]	
2-W6-10	09/09/93	1	666	7.65		
		2	670	7.64		
		3	666	7.64		
		4	667	7.63		

The column headers consist of: Constituent Name; Analysis Units; and Contractual Required Quantitation Limit/Drinking Water Standard (suffix)

Suffix s = based on Secondary Maximum Contaminant Levels in 40 CFR Part 143, National Secondary Drinking Water Regulations
w = based on additional Secondary Maximum Contaminant Levels in WAC 248-54, Public Water Supplies

Data flag:

[U]denotes that analyte concentration is below CRQL. Reported values were analytical laboratories' CRQL.

[L]denotes that analyte concentration is above MDL but below CRQL.

[B]denotes that blank associated with analyte is contaminated.

[P]denotes potential problem associated with data quality. Values are not reported.

Table C-13. Background Contamination Indicator Parameter Data for the Low-Level Waste Management Area 5. (page 5 of 6)

Well Name	Sample Date	Dupl. Sample Number	Specific Conductance µmho/cm 1/700w	Field pH 0.01/8.5s	TOC ppb 1000/.	TOX[P] ppb 10/.
2-W7-10	08/07/92	1	287	7.72	1000[U]	
		2	288	7.73	1000[U]	
		3	289	7.73	1000[U]	
		4	289	7.75	1000[U]	
2-W7-10	11/16/92	1	269	8.12	1000[U]	
		2	263	8.09	1000[U]	
		3	264	8.07	1000[U]	
		4	266	8.06	1000[U]	
2-W7-10	02/05/93	1	306	7.80	1000[U]	
		2	306	7.82	1000[U]	
		3	306	7.83	1000[U]	
		4	306	7.83	1000[U]	
2-W7-10	05/17/93	1	300	8.27	300[L]	
		2	298	8.28	300[L]	
		3	298	8.26	400[L]	
		4	299	8.25	300[L]	

The column headers consist of: Constituent Name; Analysis Units; and Contractual Required Quantitation Limit/Drinking Water Standard (suffix)

Suffix s = based on Secondary Maximum Contaminant Levels in 40 CFR Part 143, National Secondary Drinking Water Regulations

w = based on additional Secondary Maximum Contaminant Levels in WAC 248-54, Public Water Supplies

Data flag:

[U]denotes that analyte concentration is below CRQL. Reported values were analytical laboratories' CRQL.

[L]denotes that analyte concentration is above MDL but below CRQL.

[B]denotes that blank associated with analyte is contaminated.

[P]denotes potential problem associated with data quality. Values are not reported.

Table C-13. Background Contamination Indicator Parameter Data for the Low-Level Waste Management Area 5. (page 6 of 6)

Well Name	Sample Date	Dupl. Sample Number	Specific Conductance µmho/cm 1/700w	Field pH 0.01/8.5s	TOC ppb 1000/.	TOX[P] ppb 10/.
2-W11-31	12/08/92	1	641	7.94	1000[U]	
		2	680	7.94	1000[U]	
		3	599	7.93	1000[U]	
		4	595	7.92	1000[U]	
2-W11-31	03/21/93	1	714	7.84	1000[U]	
		2	716	7.86	1000[U]	
		3	717	7.84	1000[U]	
		4	712	7.84	1000[U]	
2-W11-31	06/10/93	1	729	7.67	500[L]	
		2	730	7.64	400[L]	
		3	729	7.65	400[L]	
		4	729	7.65	500[L]	
2-W11-31	09/09/93	1	716	7.68		
		2	718	7.66		
		3	722	7.71		
		4	724	7.77		

The column headers consist of: Constituent Name; Analysis Units; and Contractual Required Quantitation Limit/Drinking Water Standard (suffix)

Suffix s = based on Secondary Maximum Contaminant Levels in 40 CFR Part 143, National Secondary Drinking Water Regulations
W = based on additional Secondary Maximum Contaminant Levels in WAC 248-54, Public Water Supplies

Data flag:

[U]denotes that analyte concentration is below CRQL. Reported values were analytical laboratories' CRQL.

[L]denotes that analyte concentration is above MDL but below CRQL.

[B]denotes that blank associated with analyte is contaminated.

[P]denotes potential problem associated with data quality. Values are not reported.

Table C-14. Average Replicate Statistics--Background Indicator Parameter Data for the Low-Level Waste Management Area 5. (page 1 of 6)

Constituent (Unit)	Well Name	Sample Date	n	Average	Standard Deviation	C.V. (%)
Specific Conductance (μmho/cm)	2-W6-2	05/21/92	4	357.00	2.708	0.76
	2-W6-2	08/07/92	1	309.00	N.A.	N.A.
	2-W6-2	12/08/92	4	388.75	0.500	0.13
	2-W6-2	02/05/93	4	396.75	0.957	0.24
	2-W6-2	05/18/93	4	391.00	1.826	0.47
Field pH	2-W6-2	05/21/92	4	8.015	0.013	0.16
	2-W6-2	08/07/92	1	8.090	N.A.	N.A.
	2-W6-2	12/08/92	4	7.978	0.015	0.19
	2-W6-2	02/05/93	4	7.875	0.006	0.07
	2-W6-2	05/18/93	4	7.862	0.022	0.28
TOC (ppb)	2-W6-2	05/21/92	4	500[U]	N.A.	N.A.
	2-W6-2	08/07/92	1	500[U]	N.A.	N.A.
	2-W6-2	12/08/92	4	500[U]	N.A.	N.A.
	2-W6-2	02/05/93	4	500[U]	N.A.	N.A.
	2-W6-2	05/18/93	4	650[LB]	57.735	8.88
TOX (ppb)	2-W6-2	05/21/92	4	N.C.	N.C.	N.C.
	2-W6-2	08/07/92	1	N.C.	N.C.	N.C.
	2-W6-2	12/08/92	4	N.C.	N.C.	N.C.
	2-W6-2	02/05/93	4	N.C.	N.C.	N.C.
	2-W6-2	05/18/93	4	N.C.	N.C.	N.C.

[U]Numbers were calculated using values below CRQL by replacing such values with half of the respective CRQL.

[L]denotes analyte concentration is above MDL but below CRQL.

[B]denotes that blank associated with analyte is contaminated.

N.A. = not available. C.V. = coefficient of variation.
N.C. = not calculated.

Table C-14. Average Replicate Statistics--Background Indicator Parameter Data for the Low-Level Waste Management Area 5. (page 2 of 6)

Constituent (Unit)	Well Name	Sample Date	n	Average	Standard Deviation	C.V. (%)
Specific Conductance (μmho/cm)	2-W6-4	09/04/92	4	580.25	1.258	0.22
	2-W6-4	12/08/92	4	635.00	0	0
	2-W6-4	03/17/93	4	568.25	5.560	0.98
	2-W6-4	06/10/93	4	553.25	2.986	0.54
Field pH	2-W6-4	09/04/92	4	8.085	0.013	0.16
	2-W6-4	12/08/92	4	8.282	0.005	0.06
	2-W6-4	03/17/93	4	8.518	0.038	0.44
	2-W6-4	06/10/93	4	8.100	0.029	0.36
TOC (ppb)	2-W6-4	09/04/92	4	500[U]	N.A.	N.A.
	2-W6-4	12/08/92	4	500[U]	N.A.	N.A.
	2-W6-4	03/17/93	4	500[U]	N.A.	N.A.
	2-W6-4	06/10/93	4	450[LB]	173.205	38.49
TOX (ppb)	2-W6-4	09/04/92	4	N.C.	N.C.	N.C.
	2-W6-4	12/08/92	4	N.C.	N.C.	N.C.
	2-W6-4	03/17/93	4	N.C.	N.C.	N.C.
	2-W6-4	06/10/93	4	N.C.	N.C.	N.C.

[U]Numbers were calculated using values below CRQL by replacing such values with half of the respective CRQL.

[L]denotes analyte concentration is above MDL but below CRQL.

[B]denotes that blank associated with analyte is contaminated.

N.A. = not available. C.V. = coefficient of variation.
N.C. = not calculated.

Table C-14. Average Replicate Statistics--Background Indicator Parameter Data for the Low-Level Waste Management Area 5. (page 3 of 6)

Constituent (Unit)	Well Name	Sample Date	n	Average	Standard Deviation	C.V. (%)
Specific Conductance (μmho/cm)	2-W6-9	12/08/92	4	427.75	0.957	0.22
	2-W6-9	03/15/93	4	447.50	1.291	0.29
	2-W6-9	06/14/93	4	448.25	1.258	0.28
	2-W6-9	09/10/93	4	423.25	2.217	0.52
Field pH	2-W6-9	12/08/92	4	8.005	0.006	0.07
	2-W6-9	03/15/93	4	7.952	0.005	0.06
	2-W6-9	06/14/93	4	7.678	0.017	0.22
	2-W6-9	09/10/93	4	7.775	0.010	0.13
TOC (ppb)	2-W6-9	12/08/92	4	500[U]	N.A.	N.A.
	2-W6-9	03/15/93	4	500[U]	N.A.	N.A.
	2-W6-9	06/14/93	4	425[LB]	50.000	11.76
	2-W6-9	09/10/93	4	375[L]	50.000	13.33
TOX (ppb)	2-W6-9	12/08/92	4	N.C.	N.C.	N.C.
	2-W6-9	03/15/92	4	N.C.	N.C.	N.C.
	2-W6-9	06/14/93	4	N.C.	N.C.	N.C.
	2-W6-9	09/10/93	4	N.C.	N.C.	N.C.

[U]Numbers were calculated using values below CRQL by replacing such values with half of the respective CRQL.

[L]denotes analyte concentration is above MDL but below CRQL.

[B]denotes that blank associated with analyte is contaminated.

N.A. = not available. C.V. = coefficient of variation.
N.C. = not calculated.

Table C-14. Average Replicate Statistics--Background Indicator Parameter Data for the Low-Level Waste Management Area 5. (page 4 of 6)

Constituent (Unit)	Well Name	Sample Date	n	Average	Standard Deviation	C.V. (%)
Specific Conductance (μmho/cm)	2-W6-10	12/08/92	4	753.75	3.594	0.48
	2-W6-10	03/22/93	4	732.25	3.304	0.45
	2-W6-10	06/14/93	4	748.00	1.414	0.19
	2-W6-10	09/09/93	4	667.25	1.893	0.28
Field pH	2-W6-10	12/08/92	4	7.910	0.026	0.33
	2-W6-10	03/22/92	4	7.748	0.013	0.16
	2-W6-10	06/14/93	4	7.620	0.028	0.37
	2-W6-10	09/09/93	4	7.640	0.008	0.11
TOC (ppb)	2-W6-10	12/08/92	4	500[U]	N.A.	N.A.
	2-W6-10	03/22/93	4	500[U]	N.A.	N.A.
	2-W6-10	06/14/93	4	575[LB]	150.000	26.09
	2-W6-10	09/09/93	4			
TOX (ppb)	2-W6-10	12/08/92	4	N.C.	N.C.	N.C.
	2-W6-10	03/22/93	4	N.C.	N.C.	N.C.
	2-W6-10	06/14/93	4	N.C.	N.C.	N.C.
	2-W6-10	09/09/93	4	N.C.	N.C.	N.C.

[U]Numbers were calculated using values below CRQL by replacing such values with half of the respective CRQL.

[L]denotes analyte concentration is above MDL but below CRQL.

[B]denotes that blank associated with analyte is contaminated.

N.A. = not available. C.V. = coefficient of variation.
N.C. = not calculated.

Table C-14. Average Replicate Statistics--Background Indicator Parameter Data for the Low-Level Waste Management Area 5. (page 5 of 6)

Constituent (Unit)	Well Name	Sample Date	n	Average	Standard Deviation	C.V. (%)
Specific Conductance (μmho/cm)	2-W7-10	08/07/92	4	288.25	0.957	0.33
	2-W7-10	11/16/92	4	265.50	2.646	1.00
	2-W7-10	02/05/93	4	306.00	0	0
	2-W7-10	05/17/93	4	298.75	0.957	0.32
Field pH	2-W7-10	08/07/92	4	7.732	0.013	0.16
	2-W7-10	11/16/92	4	8.085	0.026	0.33
	2-W7-10	02/05/93	4	7.820	0.014	0.18
	2-W7-10	05/17/93	4	8.265	0.013	0.16
TOC (ppb)	2-W7-10	08/07/92	4	500[U]	N.A.	N.A.
	2-W7-10	11/16/92	4	500[U]	N.A.	N.A.
	2-W7-10	02/05/93	4	500[U]	N.A.	N.A.
	2-W7-10	05/17/93	4	325[L]	50.000	15.38
TOX (ppb)	2-W7-10	08/07/92	4	N.C.	N.C.	N.C.
	2-W7-10	11/16/92	4	N.C.	N.C.	N.C.
	2-W7-10	02/05/93	4	N.C.	N.C.	N.C.
	2-W7-10	05/17/93	4	N.C.	N.C.	N.C.

[U]Numbers were calculated using values below CRQL by replacing such values with half of the respective CRQL.

[L]denotes analyte concentration is above MDL but below CRQL.

[B]denotes that blank associated with analyte is contaminated.

N.A. = not available. C.V. = coefficient of variation.
N.C. = not calculated.

Table C-14. Average Replicate Statistics--Background Indicator Parameter Data for the Low-Level Waste Management Area 5. (page 6 of 6)

Constituent (Unit)	Well Name	Sample Date	n	Average	Standard Deviation	C.V. (%)
Specific Conductance (μmho/cm)	2-W11-31	12/08/92	4	628.75	40.003	6.36
	2-W11-31	03/21/93	4	714.75	2.217	0.31
	2-W11-31	06/10/93	4	729.25	0.500	0.07
	2-W11-31	09/09/93	4	720.00	3.652	0.51
Field pH	2-W11-31	12/08/92	4	7.932	0.010	0.12
	2-W11-31	03/21/92	4	7.845	0.010	0.13
	2-W11-31	06/10/93	4	7.652	0.013	0.16
	2-W11-31	09/09/93	4	7.705	0.048	0.62
TOC (ppb)	2-W11-31	12/08/92	4	500[U]	N.A.	N.A.
	2-W11-31	03/21/92	4	500[U]	N.A.	N.A.
	2-W11-31	06/10/93	4	450[L]	57.735	12.83
	2-W11-31	09/09/93	4			
TOX (ppb)	2-W11-31	12/08/92	4	N.C.	N.C.	N.C.
	2-W11-31	03/21/92	4	N.C.	N.C.	N.C.
	2-W11-31	06/10/93	4	N.C.	N.C.	N.C.
	2-W11-31	09/09/93	4	N.C.	N.C.	N.C.

[U]Numbers were calculated using values below CRQL by replacing such values with half of the respective CRQL.

[L]denotes analyte concentration is above MDL but below CRQL.

[B]denotes that blank associated with analyte is contaminated.

N.A. = not available. C.V. = coefficient of variation.
N.C. = not calculated.

Table C-15. Background Statistics--Contamination Indicator Parameter Data for the Low-Level Waste Management Area 5.

Constituent	Units	n	Background average	Background standard deviation	Background C.V. (%)
Specific conductance	μmhos/cm	24	519.562	167.372	32.21
Field pH		24	7.920	0.225	2.84
TOC[a]	ppb	18[c]	480.6	49.67	10.34
TOX[b]	ppb	N.C.	N.C.	N.C.	N.C.

NOTE: Background summary statistics were calculated from only those samples that had four replicate values.

[a]Background summary statistics for TOC were calculated using values below CRDL and CRQL.

[b]Background summary statistics for TOX are not calculated due to problems related to data quality.

[c]Excluding replicate average where blank associated with samples was contaminated (2-W6-2, 5/18/93; 2-W6-4, 6/10/93; 2-W6-9, 6/14/93; and 2-W6-10, 6/14/93).

N.C. = not calculated.

Table C-16. Background Contamination Indicator Parameter Data for the Single-Shell Tanks Waste Management Area T. (page 1 of 2)

Well Name	Sample Date	Dupl. Sample Number	Specific Conductance µmho/cm 1/700w	Field pH 0.01/8.5s	TOC ppb 1000/.	TOX[P] ppb 10/.
2-W10-16	07/22/91	1	880	8.01	1000[U]	
		2	880	8.00	1000[U]	
		3	888	8.00	1000[U]	
		4	885	7.99	1000[U]	
2-W10-16	09/24/91	1	880	7.33	1000[U]	
		2	876	7.33	1000[U]	
		3	877	7.34	1000[U]	
		4	873	7.36	1000[U]	
2-W10-16	10/15/91	1	858	7.52		
		2				
		3				
		4				
2-W10-16	11/25/91	1	828	7.93		
		2				
		3				
		4				

The column headers consist of: Constituent Name; Analysis Units; and Contractual Required Quantitation Limit/Drinking Water Standard (suffix)

Suffix s = based on Secondary Maximum Contaminant Levels in 40 CFR Part 143, National Secondary Drinking Water Regulations
w = based on additional Secondary Maximum Contaminant Levels in WAC 248-54, Public Water Supplies

Data flag:
[U] denotes that analyte concentration is below CRQL. Reported values were analytical laboratories' CRQL.

[P] denotes potential problem associated with data quality. Values are not reported.

Table C-16. Background Contamination Indicator Parameter Data for the Single-Shell Tanks Waste Management Area T. (page 2 of 2)

Well Name	Sample Date	Dupl. Sample Number	Specific Conductance µmho/cm 1/700w	Field pH 0.01/8.5s	TOC ppb 1000/.	TOX[P] ppb 10/.
2-W10-16	01/27/92	1	830	7.75	1000[U]	
		2	830	7.77	1000[U]	
		3	823	7.78	1000[U]	
		4	826	7.78	1000[U]	
2-W10-16	04/20/92	1	811	7.64	1000[UD]	
		2	802	7.66	1000[UD]	
		3	795	7.66	1000[UD]	
		4	801	7.67	1000[UD]	
2-W10-16	07/13/92	1	796	7.77	1000[U]	
		2	796	7.76	1000[U]	
		3	796	7.76	1000[U]	
		4	795	7.76	1000[U]	

The column headers consist of: Constituent Name; Analysis Units; and Contractual Required Quantitation Limit/Drinking Water Standard (suffix)

Suffix s = based on Secondary Maximum Contaminant Levels in 40 CFR Part 143, National Secondary Drinking Water Regulations
w = based on additional Secondary Maximum Contaminant Levels in WAC 248-54, Public Water Supplies

Data flag:
[U]denotes that analyte concentration is below CRQL. Reported values were analytical laboratories' CRQL.

[D]denotes that results are associated with a documented laboratory nonconformance.

[P]denotes potential problem associated with data quality. Values are not reported.

Table C-17. Average Replicate Statistics--Background Indicator Parameter Data for the Single-Shell Tanks Waste Management Area T.

Constituent (Unit)	Well Name	Sample Date	n	Average	Standard Deviation	C.V. (%)
Specific Conductance (μmho/cm)	2-W10-16	07/22/91	4	883.25	3.948	0.45
	2-W10-16	09/24/91	4	876.50	2.887	0.33
	2-W10-16	01/27/92	4	827.25	3.403	0.41
	2-W10-16	04/20/92	4	802.25	6.602	0.82
	2-W10-16	07/13/92	4	795.75	0.500	0.06
Field pH	2-W10-16	07/22/91	4	8.000	0.008	0.10
	2-W10-16	09/24/91	4	7.340	0.014	0.19
	2-W10-16	01/27/92	4	7.770	0.014	0.18
	2-W10-16	04/20/92	4	7.658	0.013	0.16
	2-W10-16	07/13/92	4	7.762	0.005	0.06
TOC[a] (ppb)	2-W10-16	07/22/91	4	500[U]	N.A.	N.A.
	2-W10-16	09/24/91	4	500[U]	N.A.	N.A.
	2-W10-16	01/27/92	4	500[U]	N.A.	N.A.
	2-W10-16	04/20/92[D]	4	N.C.	N.A.	N.A.
	2-W10-16	07/13/92	4	500[U]	N.A.	N.A.
TOX (ppb)	2-W10-16	07/22/91	4	472.50	141.745	30.00
	2-W10-16	09/24/91	4	617.50	53.307	8.63
	2-W10-16	01/27/92[P]	4	N.C.	N.C.	N.C.
	2-W10-16	04/20/92[P]	3	N.C.	N.C.	N.C.
	2-W10-16	07/13/92[P]	4	N.C.	N.C.	N.C.

Note: Summary statistics calculated from only those samples that had four replicate values.

[a]statistics were calculated by replacing not detected values with half of the respective CRQL.

[U]denotes calculated values are below the CRQL.

[D]statistics were not calculated due to Non-Conformance Report.

[P]replicate averages are not calculated due to problems related with data quality.

N.A. = not available. C.V. = coefficient of variation.
N.C. = not calculated.

Table C-18. Background Statistics[a]--Contamination Indicator Parameter Data for the Single-Shell Tanks Waste Management Area T.

Constituent	Units	n	Background average	Background standard deviation	Background C.V. (%)
Specific conductance	μmhos/cm	5	837	40.938	4.89
Field pH		5	7.706	0.240	3.11
TOC	ppb	4	500	N.C.	N.C.
TOX[b]	ppb	N.C.	N.C.	N.C.	N.C.

Note: Summary statistics calculated from only those samples that had replicate values.

[a]Background summary statistics for TOC were calculated using values below CRQL.

[b]Background summary statistics for TOX are not calculated due to problems related to data quality.

N.C. = not calculated.

Table C-19. Background Contamination Indicator Parameter Data for the Single-Shell Tanks Waste Management Area TX-TY.

Well Name	Sample Date	Dupl. Sample Number	Specific Conductance µmho/cm 1/700w	Field pH 0.01/8.5s	TOC ppb 1000/.	TOX[P] ppb 10/.
2-W15-22	09/24/91	1	478	7.47	1000[U]	
		2	478	7.46	1000[U]	
		3	478	7.45	1000[U]	
		4	478	7.46	1000[U]	
2-W15-22	10/16/91	1	501	7.51		
		2				
		3				
		4				
2-W15-22	01/27/92	1	456	8.30	1000[U]	
		2	450	8.32	1000[U]	
		3	451	8.31	1000[U]	
		4	449	8.32	1000[U]	
2-W15-22	04/20/92	1	446	7.67	1000[UD]	
		2	442	7.61	1000[UD]	
		3	442	7.60	1000[UD]	
		4	441	7.61	1000[UD]	
2-W15-22	07/20/92	1	449	7.75	1000[U]	
		2	447	7.74	1000[U]	
		3	448	7.72	1000[U]	
		4	444	7.73	1000[U]	

The column headers consist of: Constituent Name; Analysis Units; and Contractual Required Quantitation Limit/Drinking Water Standard (suffix)

Suffix s = based on Secondary Maximum Contaminant Levels in 40 CFR Part 143, National Secondary Drinking Water Regulations

w = based on additional Secondary Maximum Contaminant Levels in WAC 248-54, Public Water Supplies

Data flag:

[U]denotes that analyte concentration is below CRQL. Reported values were analytical laboratories' CRQL.

[P]denotes potential problem associated with data quality. Values are not reported.

[D]denotes that results are associated with a documented laboratory nonconformance.

Table C-20. Average Replicate Statistics--Background Indicator Parameter Data for the Single-Shell Tanks Waste Management Area TX-TY.

Constituent (Unit)	Well Name	Sample Date	n	Average	Standard Deviation	C.V. (%)
Specific Conductance (μmho/cm)	2-W15-22	09/24/91	4	478.00	0	0
	2-W15-22	01/27/92	4	451.50	3.109	0.69
	2-W15-22	04/20/92	4	442.75	2.217	0.50
	2-W15-22	07/20/92	4	447.00	2.160	0.48
Field pH	2-W15-22	09/24/91	4	7.460	0.008	0.11
	2-W15-22	01/27/92	4	8.312	0.010	0.12
	2-W15-22	04/20/92	4	7.622	0.032	0.42
	2-W15-22	07/20/92	4	7.735	0.013	0.17
TOC[a] (ppb)	2-W15-22	09/24/91	4	500[U]	N.A.	N.A.
	2-W15-22	01/27/92	4	500[U]	N.A.	N.A.
	2-W15-22	04/20/92[D]	4	N.C.	N.C.	N.C.
	2-W15-22	07/20/92	4	500[U]	N.A.	N.A.
TOX[a] (ppb)	2-W15-22	09/24/91	4	1246.25	245.404	19.69
	2-W15-22	01/27/92[P]	4	N.C.	N.C.	N.C.
	2-W15-22	04/20/92[P]	4	N.C.	N.C.	N.C.
	2-W15-22	07/20/92[P]	4	N.C.	N.C.	N.C.

Note: Summary statistics calculated from only those samples that had four replicate values.

[a]statistics were calculated by replacing not detected values with half of the respective CRQL.

[U]denotes calculated values are below the CRQL.

[D]statistics were not calculated due to Non-Conformance Report.

[P]replicate averages are not calculated due to problems related to data quality.

N.A. = not available. C.V. = coefficient of variation.
N.C. = not calculated.

Table C-21. Background Statistics--Contamination Indicator Parameter Data for the Single-Shell Tanks Waste Management Area TX-TY.

Constituent	Units	n	Background average	Background standard deviation	Background C.V. (%)
Specific conductance	µmhos/cm	4	454.812	15.866	3.49
Field pH		4	7.782	0.371	4.77
TOC[a]	ppb	3	500	N.C.	N.C.
TOX[b]	ppb	N.C.	N.C.	N.C.	N.C.

Note: Summary statistics calculated from only those samples that had replicate values.

[a]Background summary statistics for TOC were calculated using values below CRQL.

[b]Background summary statistics for TOX are not calculated due to problems associated with data quality.

N.C. = not calculated.

Table C-22. Background Contamination Indicator Parameter Data for the Single-Shell Tanks Waste Management Area U. (page 1 of 2)

Well Name	Sample Date	Dupl. Sample Number	Specific Conductance µmho/cm 1/700w	Field pH 0.01/8.5s	TOC ppb 1000/.	TOX[P] ppb 10/.
2-W18-25	04/21/92	1	192	7.60	1000[UD]	
		2	192	7.62	1000[UD]	
		3	192	7.62	1000[UD]	
		4	191	7.62	1000[UD]	
2-W18-25	07/20/92	1	196	6.78[F]	1000[U]	
		2	196	6.81[F]	1000[U]	
		3	199	6.84[F]	1000[U]	
		4	200	6.86[F]	1000[U]	
2-W18-25	11/10/92	1	237	7.33	1000[U]	
		2	235	7.35	1000[U]	
		3	234	7.35	1000[U]	
		4	232	7.37	1000[U]	
2-W18-25	03/04/93	1	265	7.95	1000[U]	
		2	260	7.95	1000[U]	
		3	264	7.93	1000[U]	
		4	264	7.93	1000[U]	

The column headers consist of: Constituent Name; Analysis Units; and Contractual Required Quantitation Limit/Drinking Water Standard (suffix)

Suffix s = based on Secondary Maximum Contaminant Levels in 40 CFR Part 143, National Secondary Drinking Water Regulations

w = based on additional Secondary Maximum Contaminant Levels in WAC 248-54, Public Water Supplies

Data flag:

[U]denotes that analyte concentration is below CRQL. Reported values were analytical laboratories' CRQL.

[P]denotes potential problem associated with data quality. Values are not reported.

[D]denotes laboratory Non-Conformance Report was issued.

[F]denotes that data are inconsistent with the rest of analytical results. RADE has been submitted for further investigation.

Table C-22. Background Contamination Indicator Parameter Data for the Single-Shell Tanks Waste Management Area U. (page 2 of 2)

Well Name	Sample Date	Dupl. Sample Number	Specific Conductance µmho/cm 1/700w	Field pH 0.01/8.5s	TOC ppb 1000/.	TOX[P] ppb 10/.
2-W18-31	04/22/92	1	249	7.90	1000[U]	
		2	249	7.91	1000[U]	
		3	249	7.91	1000[U]	
		4	251	7.92	1000[U]	
2-W18-31	07/20/92	1	259	8.06	1000[U]	
		2	259	8.06	1000[U]	
		3	259	8.06	1000[U]	
		4	259	8.06	1000[U]	
2-W18-31	11/10/92	1	258	8.25	1000[U]	
		2	259	8.25	1000[U]	
		3	257	8.25	1000[U]	
		4	258	8.25	1000[U]	
2-W18-31	03/04/93	1	262	8.24	1000[U]	
		2	263	8.21	1000[U]	
		3	262	8.20	1000[U]	
		4	264	8.29	1000[U]	

The column headers consist of: Constituent Name; Analysis Units; and Contractual Required Quantitation Limit/Drinking Water Standard (suffix)

Suffix s = based on Secondary Maximum Contaminant Levels in 40 CFR Part 143, National Secondary Drinking Water Regulations

w = based on additional Secondary Maximum Contaminant Levels in WAC 248-54, Public Water Supplies

Data flag:

[U]denotes that analyte concentration is below CRQL. Reported values were analytical laboratories' CRQL.

[P]denotes potential problem associated with data quality. Values are not reported.

Table C-23. Average Replicate Statistics--Background Indicator Parameter Data for the Single-Shell Tanks Waste Management Area U. (page 1 of 2)

Constituent (Unit)	Well Name	Sample Date	n	Average	Standard Deviation	C.V. (%)
Specific Conductance (μmho/cm)	2-W18-25	04/21/92	4	191.75	0.500	0.26
	2-W18-25	07/20/92	4	197.75	2.062	1.04
	2-W18-25	11/10/92	4	234.50	2.082	0.89
	2-W18-25	03/04/93	4	263.25	2.217	0.84
Field pH	2-W18-25	04/21/92	4	7.615	0.010	0.13
	2-W18-25	07/20/92	4	6.822[F]	0.035	0.51
	2-W18-25	11/10/92	4	7.350	0.016	0.22
	2-W18-25	03/04/93	4	7.940	0.012	0.15
TOC[a] (ppb)	2-W18-25	04/21/92[D]	4	N.C.	N.C.	N.C.
	2-W18-25	07/20/92	4	500[U]	N.A.	N.A.
	2-W18-25	11/10/92	4	500[U]	N.A.	N.A.
	2-W18-25	03/04/93	4	500[U]	N.A.	N.A.
TOX (ppb)	2-W18-25	04/21/92[P]	4	N.C.	N.C.	N.C.
	2-W18-25	07/20/92[P]	4	N.C.	N.C.	N.C.
	2-W18-25	11/10/92[P]	4	N.C.	N.C.	N.C.
	2-W18-25	03/04/93[P]	4	N.C.	N.C.	N.C.

Note: Summary statistics calculated from only those samples that had four replicate values.

[a]statistics were calculated by replacing not detected values with half of the respective CRQL.

[U]denotes calculated values are below the CRQL.

[D]denotes replicate average is not calculated due to laboratory Non-Conformance Report.

[P]replicate averages are not calculated due to problems related with data quality.

[F]denotes that data are inconsistent with the rest of analytical results. RADE has been submitted for further investigation.

N.A. = not available. C.V. = coefficient of variation.
N.C. = not calculated.

Table C-23. Average Replicate Statistics--Background Indicator Parameter Data for the Single-Shell Tanks Waste Management Area U. (page 2 of 2)

Constituent (Unit)	Well Name	Sample Date	n	Average	Standard Deviation	C.V. (%)
Specific Conductance (μmho/cm)	2-W18-31	04/22/92	4	249.50	1.000	0.40
	2-W18-31	07/20/92	4	259.00	0	0
	2-W18-31	11/10/92	4	258.00	0	0
	2-W18-31	03/04/93	4	262.75	0.957	0.36
Field pH	2-W18-31	04/22/92	4	7.910	0.008	0.10
	2-W18-31	07/20/92	4	8.060	0	0
	2-W18-31	11/10/92	4	8.250	0	0
	2-W18-31	03/04/93	4	8.235	0.040	0.49
TOC[a] (ppb)	2-W18-31	04/22/92	4	500[U]	N.A.	N.A.
	2-W18-31	07/20/92	4	500[U]	N.A.	N.A.
	2-W18-31	11/10/92	4	500[U]	N.A.	N.A.
	2-W18-31	03/04/93	4	500[U]	N.A.	N.A.
TOX (ppb)	2-W18-31	04/22/92[P]	4	N.C.	N.C.	N.C.
	2-W18-31	07/20/92[P]	4	N.C.	N.C.	N.C.
	2-W18-31	11/10/92[P]	4	N.C.	N.C.	N.C.
	2-W18-31	03/04/93[P]	4	N.C.	N.C.	N.C.

Note: Summary statistics calculated from only those samples that had four replicate values.

[a]statistics were calculated by replacing not detected values with half of the respective CRQL.

[U]denotes calculated values are below the CRQL.

[P]replicate averages are not calculated due to problems related with data quality.

N.A. = not available. C.V. = coefficient of variation.
N.C. = not calculated.

Table C-24. Background Statistics[a]--Contamination Indicator Parameter Data for the Single-Shell Tanks Waste Management Area U.

Constituent	Units	n	Background average	Background standard deviation	Background C.V. (%)
Specific conductance	μmhos/cm	8	239.562	29.216	12.20
Field pH		8 7*	7.772 7.909*	0.490 0.328*	6.30 4.15*
TOC	ppb	7**	500	N.C.	N.C.
TOX[b]	ppb	N.C.	N.C.	N.C.	N.C.

Note: Summary statistics calculated from only those samples that had replicate values.

[a]Background summary statistics for TOC were calculated using values below CRQL.

[b]Background summary statistics for TOX are not calculated due to problems related to data quality.

*Excluding inconsistent pH replicate average, 6.822, of samples collected on 7/20/92 from well 2-W18-25.

**Excluding TOC results from samples collected on 4/21/92 from well 2-W18-25 due to laboratory Non-Conformance Report.

N.C. = not calculated.

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